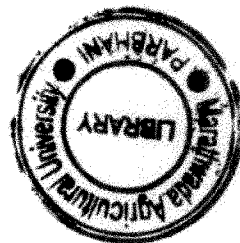


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MANAGEMENT OF POWERY MILDEW OF PEA INCITED BY
Erysiphe polygoni DC.

By
PERKA SOUNDARYA MALLAIAH
B.Sc. (AGRI.)



MASTER OF SCIENCE
(Agriculture)
IN
PLANT PATHOLOGY

T-7319

DEPARTMENT OF PLANT PATHOLOGY
COLLEGE OF AGRICULTURE, LATUR
VASANTRAO NAIK MARATHWADA KRISHI
VIDYAPEETH,
PARBHANI, (M.S.), INDIA

2014

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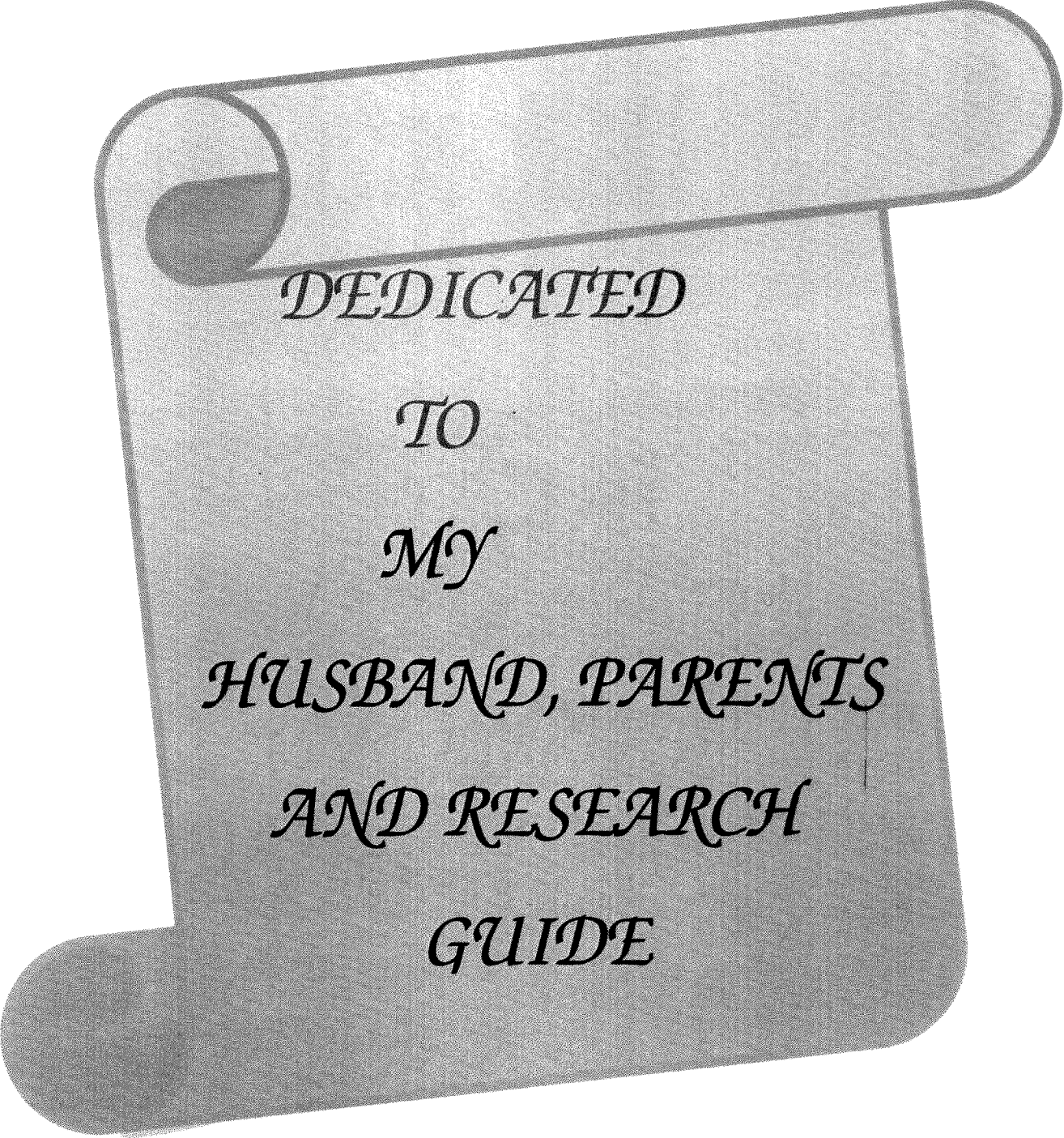
DISSERTATION

Submitted to
Vasantrao Naik Marathwada Krishi Vidyapeeth,
Parbhani
In partial fulfilment of the requirements
for the Degree of

MASTER OF SCIENCE
(Agriculture)
IN
PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY
COLLEGE OF AGRICULTURE, LATUR
VASANTRAO NAIK MARATHWADA KRISHI
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PARBHANI, (M.S.), INDIA

2014



DEDICATED

TO

My

HUSBAND, PARENTS

AND RESEARCH

GUIDE

CANDIDATE'S DECLARATION

I hereby declare that the dissertation

or part thereof has not been

previously submitted by me

for a degree of any

University or

Institute.

Place : Latur

Date: 30 / 05 / 2014

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CERTIFICATE – I

This is to certify that the dissertation entitled “**MANAGEMENT OF POWDERY MILDEW OF PEA INCITED BY *Erysiphe polygoni* DC**” submitted by Miss **PERKA SOUNDARYA MALLAIAH** to the **Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani** in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **PLANT PATHOLOGY** is record of original and bonafide research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree.

I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any university.

Place :Latur

Date : 30/05/2014



S. J. Magar

Research Guide
and
Chairman
Advisory Committee

CERTIFICATE – II

This is to certify that the dissertation entitled “**MANAGEMENT OF POWDERY MILDEW OF PEA INCITED BY *Erysiphe polygoni* DC.**” submitted by Miss. **PERKA SOUNDARYA MALLAIAH** to the **Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani** in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **PLANT PATHOLOGY** has been approved by the student’s advisory committee after oral examination in collaboration with the external examiner.


External Examiner


S. J. Magar

Research Guide

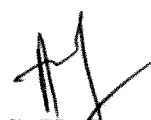
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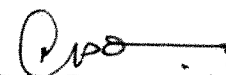
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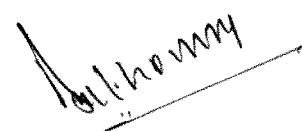
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ABBREVIATIONS

%	-	Per cent
@	-	At the rate of
C.D.	-	Critical difference
Cm	-	centimeter (s)
DAS	-	Days After Sowing
Dia.	-	Diameter
e.g.	-	Exempli Gratia (for Example)
<i>et al.</i>	-	and others
etc.	-	Etcetera
Fig.	-	Figure (s)
ha.	-	hectares (s)
hrs.	-	Hours
i.e.	-	That is
Kg.	-	Kilogram (s)
m.	-	meter (s)
mm.	-	millimeter
No.	-	number (s)
°C.	-	Degree Celsius
PDI	-	Per cent Disease Intensity
PDC	-	Per cent Disease Control
S.E.	-	Standard error
sp.	-	species
T	-	Treatment
<i>viz.,</i>	-	videlicet (namely)
Var.	-	Variety

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PLACE: LATUR

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P. Soundarya
(Perka Soundarya)

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INTRODUCTION

CHAPTER I

INTRODUCTION

Pea (*Pisum sativum* L.) is a valuable vegetable crop all over the world. It belongs to the family Leguminaceae and is commonly called as Pea, Dry pea, (UK and USA), Batani (Ind), Erbese (Ger), Ater (Eth), Pois (Fra), Takarmany borso (Hun). Duke (1981) reported that peas are of four types i.e. Garden pea (*Pisum sativum* spp. *hortense* (Asch. & Graebn.), Field pea (*P. sativum* spp. *arvense* (L.) Poir.), Edible podded peas (*P. sativum* spp. *Macrocarpon*) and Early dwarf pea (*P. sativum* var *humile*). Pea is a cool season crop. It is probably originated in Southwestern Asia, possibly in Northwestern India, Pakistan or adjacent areas of former USSR and Afghanistan.

Peas are cultivated for the fresh green seeds, tender green pods, dried seeds and foliage and cooked as a vegetable, marketed fresh, canned and frozen. Dry peas are used as whole, split as dhal, roasted, parched, boiled and made into flour (Davies *et al.*, 1985). Pea seeds contain trypsin and chymotrypsin, which could be used for contraceptive, ecobolic, fungistatic and spermicide. Oil from ripened seed has antisex harmonic effects: produces sterility and antagonizes effect of male hormone (Duke, 1981). They are excellent source of heart healthy food that may be beneficial to the prevention of cardiovascular disease. Dry peas are used as livestock feed and human food, but recent reports have described as field peas are potential ingredients for aquaculture feeds.

Pea is a highly nutritious crop. On dry weight basis, whole green pea contains fat 1.4 g, carbohydrates 64.8 g, total fiber 16.3 g, insoluble fiber 14.6 g, sucrose 3 g, protein 23.3 g, calcium 74.4 mg, iron 5.9 mg, potassium 1080 mg, vitamin C 0.55 mg, thiamin 0.51 mg, riboflavin 0.18 mg, niacin 1.55 mg, vitamin B₆ 0.05 mg and folate 35.5 mg per 100 g.

India is recognized globally as the major producer of pulses contributing 25 per cent to the global production. In India, area, production and productivity of pea during 2012-13, was about 4.18 lakh ha, 3,942 thousand MT and 9.4 MT/ha and in Maharashtra, it was about 0.1 lakh ha, 51 thousand MT and 5.1 MT/ha, respectively (Anonymous, 2013). The major producing countries of field pea are Russia and China, followed by Canada, Europe, Australia and the United States. The major producing states in India are Bihar, Uttar Pradesh, Punjab, Haryana,

Himachal Pradesh, Odisha and Karnataka. Uttar Pradesh ranks first in production. Pea is the predominant export crop in world trade and represents about 40% of the total trade in pulses. The major exporting countries, excluding the European Economic Commission (EEC), are Australia, Canada and the USA. Field pea is grown on an area of over 25 million acres worldwide. The majority (over 70 percent) of the dry pea produced in the United States is exported. Most of the peas from USA were exported to India, Haiti, Peru, and Philippines.

In general, there is low productivity of pulses including Pea. Because, the crop is grown on marginal lands, low rainfall areas, poor management, poor crop husbandry and susceptibility to pests and diseases. Major obstacles in the way of increased pea production are the diseases caused by the fungal, viral and bacterial pathogens.

The fungal diseases includes *Ascochyta pisi* (*Ascochyta* blight), *Cladosporium pisicola* (leaf spot or scab), *Erysiphe polygoni* (powdery mildew), *Fusarium oxysporum* f. sp. *pisii* (wilt), *Peronospora pisi* (downy mildew), *Pythium* spp. (pre-emergence damping-off), *Botrytis cinerea* (grey mold), *Aphanomyces euteiches* (common root rot), *Thielaviopsis basicola* (black root rot) and *Sclerotinia sclerotiorum* (*Sclerotinia* white mold). Viral diseases are Pea Early Browning Virus (PEBV), Pea Enation Mosaic virus (PEMV), Pea Mosaic Virus (PMV), Pea Top Yellows (PTY), Pea Seed-borne Mosaic Virus (PSbMV) and Pea Streak Virus (PSV), while the most important bacterial disease is bacterial blight caused by *Pseudomonas pisi*. Among the fungal diseases, powdery mildew incited by *Erysiphe polygoni* DC considered as one of the most and devastating disease of the pea which results in heavy yield losses.

Powdery mildew (*Erysiphe polygoni* DC) is one of the most important disease and reported to occur worldwide in the countries viz., India, Bangladesh, Brazil, Philippines, South Australia, SriLanka, Taiwan, Thailand, Tropical Africa, France, USA, Pakistan, China, Russia, Canada and many other countries. In India, powdery mildew (*Erysiphe polygoni* DC) was reported to occur and cause heavy quantitative and qualitative losses in pea, mungbean, urdbean, methi and many other important pulse crops grown in the states of Maharashtra, Karnataka, Andhra Pradesh, Orissa, Tamilnadu and Madhya Pradesh (Khosla *et al.*, 1988). The disease was reported to occur extensively and regularly in Maharashtra state on the crops like mungbean, mustard and pea (Zote *et al.*, 1985).

The disease can appear at any stage of the crop/plant growth but is more severe at flowering and continues up to the crop maturity. The pathogen attacks all the green, aerial plant parts including leaves, stem, branches, flowers and pods. Initially, the disease appears on older leaves at bottom of the pea plants. Small, scattered, circular or irregular white powdery spots are formed on the upper surface of the leaves. White powdery growth of the fungus further coalesce and eventually cover the entire leaf surface spreading further on the lower surface of the leaves. After ageing white colour powder is gradually changed to grayish, brown coloured and affected leaves turn yellow brown, curl and dry before defoliation.

Under severe incidence, the disease can also spread on the stem, branches, flowers and pods. Small-scattered white powdery patches appear on stem, flowers and pods. Immature pods are more prone to the disease. Whitish powdery mass of the fungus covers entire surface of the pods and pods get gradually shrivelled and eventually dry which leads to improper seed setting, reduction in seed number, size and seed weight, causing accountable yield losses in pea crop.

The yield losses were reported to the tune of 50 to 90% when the intensity was high at pod formation stage (Surwase *et al.*, 2009).

Keeping in view, the economic importance of the crop and yield losses caused by powdery mildew in pea, present studies were undertaken with the following objectives.

1. To study the efficacy of newer fungicides against powdery mildew of pea.
2. To study the efficacy of botanicals and bioagents against powdery mildew of pea.
3. To screen pea varieties against powdery mildew of pea.



REVIEW OF LITERATURE



CHAPTER II

REVIEW OF LITERATURE

The literature available on powdery mildew incited by *Erysiphe polygoni* DC especially of pea, mungbean, greengram, soybean, methi, urdbean, and other host plants and powdery mildew caused by other species of *Erysiphe* particularly, in respect of their occurrence, distribution, symptomatology, yield losses, pathogenicity, management, sowing dates and germplasm screening are reviewed under following paragraphs.

2.1 The pathogen

Powdery mildew of pea is caused by *Erysiphe polygoni* DC (Class: Ascomycetes, Order: *Erysiphales*, Family: *Erysiphaceae*). The fungus is ectoparasitic and draws nutrients from the host through haustoria. Oidia/conidia are produced in chains which are ovate, hyaline, thin walled measuring 20-25 x 10-15 μm . Late in the season, cleistothecia are produced on the host tissues with hyaline flexuous appendages containing 2 to 8 asci and each ascus contains 4 to 8 ascospores (Salmon, 1900 and Linnaeus, 1976).

Erysiphe polygoni DC, inciting powdery mildew disease in pea is one of the most common pathogen of the world and infecting host plants belonging to more than 32 families (Salmon, 1900).

Yarwood (1936) reported that the fungus *Erysiphe polygoni* DC produce cleistothecia, the sexual fruiting bodies, late in the season during adverse climatic conditions. Each cleistothecium contains 2 to 8 asci measuring 46-72x30-45 μm in size and each ascus contain 4 to 8 ascospores measuring 19-25x9-14 μm in size.

The pathogen has also been reported to infect a wide range of host plants viz. *Cucumis melo* L., *Cucumis sativum* L., *Dacus carota*, *Coriandrum sativum*, *Pisum sativum* and *Trigonella foenum-graecum* from Bombay Presidency (Uppal *et al.*, 1934); *Lycopersicon esculantum*, *Lathyrus odoratus* (Vasudeva, 1960) and cowpea (Jhooty and Munshi, 1978).

Morphology of *Erysiphe polygoni* was studied by several workers and they reported the fungus as obligate parasite producing amphigeous whitish to dirty

white mycelium and hyaline barrel shaped, granular conidia measuring 32.58x15.59 μm (Yarwood, 1957).

Hans and Bosewinkel (1980) reported the conidial size of *Erysiphe polygoni* as 38.4x14.3 and 37.0x19.0 μm infecting green gram and black gram, respectively.

Rangaswami (1988) reported that ascospores contained in overwintering cleistothecia in soil as the primary source of infection which infect first the lower leaves near the soil and the secondary spread/infection through conidia.

Jhooty and Munshi (1990) studied the presence of mycelium, conidia and conidiophores of *Erysiphe polygoni* on the surface of naturally infected or artificially inoculated plants. The results did not reveal the presence of mycelium internally or externally in seeds from heavily infected pods and seeds produced healthy plants under protected conditions. A survey of the conidial stage on pea, suggested that powdery mildew survives as mycelium and conidia on the host.

Akhtar *et al.* (2009) studied that towards crop maturity, the cleistothecia bearing myceloid appendages appeared as black spots scattered on the surface of mycelial growth. Cleistothecia measured 80-95 μm with 6-8 ovate and sessile asci measuring 50-75x10-15 μm .

Gupta and Bharat (2010) observed that conidiophores were upright, hyaline, bearing conidia either singly or in chains. Conidia were hyaline, ovate to barrel-shaped, unicellular and measured 30-45x 10-20 μm .

2.2 Occurrence and distribution

Powdery mildew of pea is caused by *Erysiphe polygoni* DC and it was occurred on varieties of crops namely: pea, mungbean, urdbean, commonbean, limabean, *Lathyrus*, methi, coriander, lucern, soybean, sugarbeet, carrot, cowpea, lentil, clover, turnip, cabbage, mustard, cumin, *Medicago*, *Vicia*, *Lupines*, *Lens esculanta*, *Swedes*, *Opium poppy*, *Trifolium dubium*, *Saunf* and other crops.

Erysiphe polygoni DC, inciting powdery mildew of pea, mungbean and urdbean has been reported to cause infections in the wide range of leguminous and non-leguminous crop plants. It is one of the most important disease and reported to

occur worldwide in the countries viz. India, Bangladesh, Brazil, Philippines, South Australia, Srilanka, Taiwan, Thailand, Tropical Africa, France, USA, Pakistan and many other countries (Zaumeyer and Thomas, 1957 and Soria and Quebral, 1973).

Powdery mildew disease was reported to occur extensively and regularly in Maharashtra state on the crops like pea, mungbean, urdbean and mustard (Moghe *et al.*, 1982 and Zote *et al.*, 1985).

Butler first reported the disease in India from Pusa (Bihar) during 1918 and since then it had been reported to be of common occurrence in the country. In India, powdery mildew was reported to occur and cause heavy quantitative and qualitative losses in mungbean in the states of Maharashtra, Karnataka, Andhra Pradesh, Orissa, Tamilnadu and Madhya Pradesh (Grewal, 1988 and Khosla *et al.*, 1988).

Khodke *et al.* (2006) observed the powdery mildew occurred as white floury patches on the upper surface of leaves, which were small in size and scattered. At first, fine white mycelium developed on the surface of leaves. The patches enlarged and merged giving the appearance of white floury powder covering on the leaf surface. Infection was also observed on pods and stems of soybean of self-sown crop during January and February.

Akhtar *et al.* (2009) reported that powdery disease on lentil in February 2007 was noticed at several locations including Kanke, Boreya, Mandar and Namkom villages of Ranchi district of Jharkhand state.

Gupta and Bharat (2010) reported that French bean crop grown under protected cultivation at Nauni was found severely infected with powdery mildew disease.

2.3 Yield losses

Quantitative and qualitative yield losses incurred by powdery mildew (*Erysiphe polygoni* DC) disease in the crops like pea, mungbean, urdbean, methi and other crops were reported earlier by several workers.

Heavy reduction in pod formation and grain yield to the tune of 23 to 39% in pea due to powdery mildew intensity were also reported by several workers (Munjal *et al.*, 1963 and Srivastava *et al.*, 1973).

Raut and Wangikar (1979) reported 34.50%, 42.31%, 31.81% and 50.48% reductions in pod number, pod weight, grain size and 100 seed weight of pea respectively due to heavy infection of powdery mildew disease.

Gohil *et al.* (1988) studied the influence of powdery mildew (*Erysiphe polygoni* DC.) intensity on yield and yield contributing traits in cumin in Gujrat and reported 19.6% losses in grain yield.

Khosla *et al.* (1988) reported 30-35% yield losses in mungbean and urdbean due to powdery mildew disease incidence.

Amin and Ramachander (1989) observed as *Erysiphe polygoni* caused yield losses up to 92% in peas.

Singh *et al.* (1991) reported 65-70% losses in yield of mungbean varieties, which were severely affected by powdery mildew.

Ayub *et al.* (1996) reported considerable reduction in the number of pods/plant, no. of grain/pod and 100 seed weight and also reported 29.88% losses in yield of black gram due to powdery mildew disease incidence.

Kapoor and Thakur (1997) reported 17% losses in grain yield of pea due to powdery mildew disease incidence.

Rathi *et al.* (2002) studied reduction in growth and yield parameters of two susceptible fenugreek (*Trigonella foenum-graecum*) cultivars (HM 65 and T 8) due to powdery mildew disease caused by *Erysiphe polygoni* [*Erysiphe betae*] and *Leveillula taurica*. More than 60% disease intensity reduced 22.8-25.6, 16.2-18.8 and 14.3-17.2% pods per plant, seeds per pod and test weight, respectively.

Sharma and Sharma (2002) and Banyal and Rana (2003) also reported pod yield losses in pea to the tune of 40.8% and 38.7%, respectively due to heavy incidence of powdery mildew disease.

Som-Prakash and Saharan (2002) reported losses in fenugreek yield due to powdery mildew (*Erysiphe polygoni* and *Leveillula taurica*) disease up to 27-33%.

Heavy grain yield losses in mungbean and urdbean to the tune of 25-40% (Sone *et al.*, 2002), 30-40% (Singh and Sirohi, 2003) and 32-40% (Dhutraj *et al.*, 2005) were reported due to heavy incidence of powdery mildew disease.

Dakshayani and Mummigatti (2004) reported the number of pods per plant were reduced by 29%, the number of seeds per pod by 27% and the test weight by 13% in unprotected plants. The yield reduction in infected plants was 30% as compared with the control in green gram.

Surwase *et al.* (2009) studied that pea powdery mildew disease has been reported to attain maximum intensity during pod formation stage of the crop and thereby caused heavy grain yield losses to the tune of 50- 90%.

Akhileshwari *et al.* (2012) studied that the losses due to powdery mildew is proportionate to the disease intensity and varies considerably depending on the stage of the plant growth at which disease occurs.

2.4 Pathogenicity

The literature available on the proved pathogenicity of the powdery mildew disease of mungbean, urdbean and pea in particular and of other crops in general is being reviewed herein the following paragraphs.

Rathi (1998) studied that cuticular thickness plays an important role in the resistance/susceptibility of pea (*Pisum sativum*) varieties to powdery mildew (*Erysiphe polygoni*) and reported that resistant varieties had thicker cuticles of the upper (2.85-3.47 μm) and lower (2.79-3.24 μm) leaf surfaces, compared to the leaves of susceptible varieties (2.45-2.79 and 2.39-2.68 μm , respectively).

Som Prakash and Saharan (1999) studied that infection of fenugreek plants by *Erysiphe polygoni* was very high from 71-75% under controlled temperature conditions of 20-22 °C in comparison to fluctuating temperature of 8-19°C where only 56% infection was observed.

Som-Prakash and Saharan (2000) studied effect of temperature, darkness and light conditions on the conidial germination of *Erysiphe polygoni* isolated from fenugreek (*Trigonella foenum-graecum*) leaves. Conidial germination was observed for 24 hrs at 19-23°C and found to improve up to 21°C and decline at higher temperatures. Darkness inhibited and light stimulated germination of *E. polygoni*. Under light conditions there was improvement in conidial germination up to 34% at 21°C. After 22°C there was no significant increase in conidial germination.

Shete and Munjal (2002) studied the role of sugars and lignins in susceptibility or resistance to powdery mildew (*Erysiphe polygoni*) in mung bean, seeds of two susceptible cultivars (AKM 8802 and Kopergaon) and two resistant mung bean cultivars (Phule M-9339 and TARM-18) were tested. It was observed that higher reducing sugar levels in mungbean leaves may increase disease susceptibility, while, the higher lignin content may be involved in offering resistance to powdery mildew.

Katoch (2006) proved the inoculation of pea leaves with spores of *Erysiphe polygoni* f. sp. *pisi* that's resulted in the appearance of a new protein band at 24 hrs after inoculation, followed by an increase in the total protein content. Treatment with 5 mm, SA appeared to mimic the effect of inoculation with *E. polygoni* on the synthesis of the new protein. This response may have implications in the development of plant protection strategies.

Kumar and Gupta (2006) reported that conidial germination and germ tube length recorded maximum at 25°C. High relative humidity (100%) favoured conidial germination and germ tube length. Mean temperature i. e. 19.5 to 23°C and 18 to 21°C favoured disease development in the field, respectively.

2.5 Management of powdery mildew with fungicides

Pea cultivation all over the country including Marathwada region of Maharashtra state has been experiencing the serious menace of powdery mildew incidence. Most of the pea cultivars presently under cultivation are highly susceptible to the disease. Therefore, the chemical control measure appears to be the only suitable alternative for the management of powdery mildews using protective and systemic fungicides, especially those of EBI (Ergosterol Biosynthesis Inhibitors) fungicides.

The literature available on the chemical, bio agents and botanical management of the powdery mildews of mungbean, urdbean and peas in particular and of other crops in general is being reviewed here in the following paragraphs.

Srivastava *et al.* (1973) reported that sulphur dust, cosan (80% sulphur), elosal (80% elemental sulphur), karathane WD (80% dinitro phenyl crotonate) and thiovit (80% elemental sulphur) sprays controlled the disease satisfactorily and also increased the yield substantially.

Nema and Krishna (1982) tested five fungicides against powdery mildew of pea and reported that 3 sprays of either karathane (0.05%), sulfex (0.3%) or calixin (0.05%) at 15 days interval gave significant control of the disease with significantly higher grain yields over untreated check. They also reported maximum cost-benefit ratio with karathane followed by sulfex and calixin.

Suhag and Rana (1984) evaluated four fungicides against powdery mildew of pea and reported significant reduction in the disease severity with 1-2 sprays of either calixin (0.1%) or karathane (0.1%) followed by bavistin (0.1%) and sulfex (0.3%).

Khosla *et al.* (1988) evaluated five fungicides against powdery mildew of mung/urdbean and reported that karathane (0.1%) gave lowest per cent disease intensity (27.46) followed by bavistin (27.94), bayleton (30.81), microsulf (33.63) and calixin (35.32). Significantly highest grain yields over control were also reported with all fungicidal sprays.

Das and Narain (1990) evaluated five fungicides against powdery mildew of mungbean and reported that all fungicides tested (bavistin, topsin-M, karathane, sulfex and derosal) significantly reduced the disease severity over unsprayed control. They also reported that 2 sprayings of bavistin (0.1%), followed by topsin-M (0.1%), karathane (0.1%) and sulfex (0.4%) resulted maximum reduction in disease intensity with significantly higher grain yield over untreated control. The highest cost: benefit ratio was reported with sulfex followed by bavistin.

Kunkaliker and Padaganur (1990) reported that among six fungicides evaluated, tridemorph resulted in the reduction of the disease by 87.72 per cent. Carbendazim reduced the disease by 73.05 and 73.12 per cent at 0.5 and 0.1 per cent concentrations, respectively. Wettable sulphur (0.1 and 0.2%) reduced the disease by

61.91 % and 69.49%, respectively. Mancozeb, ziram and copper oxychloride could reduce the disease by 58.11, 58.05 and 56.67%, respectively.

Mishra and Krishna (1990) reported calixin and karathane (each 0.05%) is effective in controlling powdery mildew of pea by 24.22 and 51.81%, respectively over unsprayed control.

Maheshwari *et al.* (1992) evaluated seven fungicides (acrex [dinobuton], bayelton [bayelton, tridemefon], bavistin [carbendazim], calixin [tridemorph], karathane [dinocap], sulfex [sulfur] and saprol [triforine] for control of powdery mildew of pea. Maximum disease control (94%) was achieved with bayleton, followed by calixin, acrex and karathane. Saprol was the least effective (76%).

Upadhyaya and Singh (1994) obtained the significant control of powdery mildew of pea with calixin (0.1%) sprayed for 4 times at 15 days interval with highest yield.

Kapoor and Thakur (1997) evaluated three systemic and two protectant fungicides against powdery mildew of pea and reported that one spray of bayleton followed by two sprays of karathane gave significantly effective control of the disease with significant reduction in disease intensity and increase in the grain yield.

Gupta and Shyam (1998) evaluated the fungicides i.e. tridemefon, hexaconazole, difenconazole, flusilazole, fenarimol, penconazole, mancozeb and chlorothalonil for the control of pea powdery mildew (*Erysiphe polygoni*). Tridemefon (0.05%) sprays were highly effective in reducing the severity of powdery mildew.

Mathur and Shekhawat (1988) tested four fungicides namely sulfex (0.3%), karathane LC (0.1%), calixin (0.1%) and bavistin (0.1% and 0.05%) against two checks viz., water spray and no treatment. Results showed that the four fungicides can effectively control the powdery mildew in peas and increase the crop yields when applied timely.

Som Prakash and Saharan (1999) reported that for the control of powdery mildew disease, three sprays of karathane @ 0.1% were found most

effective with more than 65 per cent disease control and more than 41 per cent increase in yield.

Sharma (2000) studied the occurrence and control of *Erysiphe pisi* on peas (*Pisum sativum*), disease severity was 46.4% to 53.4%. Four sprays of 0.1% karathane gave effective control of *E. pisi* on the variety Lincon, while 2 sprays on the variety Palam Priya controlled the disease.

Rettinassababady *et al.* (2000) studied treatments of carbendazim (0.1%) and mancozeb (0.2%) and they were proved superior over the other treatments in reducing the incidence of powdery mildew of black gram and increasing the yield.

Khunti *et al.* (2002) evaluated ten fungicides against powdery mildew of mungbean and reported contaf (0.05%), calixin (0.04%), karathane (0.024%), carbendazim (0.025%) and sulfex (0.02%) as most effective in controlling powdery mildew of mungbean. Based on cost : benefit ratio, they reported contaf as most economical fungicide followed by carbendazim, calixin and sulfex.

Saxena and Saxena (2002) evaluated the fungicides carbendazim (0.05%), that's retarded powdery mildew of mungbean with low (11.44%) powdery mildew intensity. Other fungicides like tridemorph (0.075%) and penconazole (0.05%) were equally effective against the mildew disease, where the disease intensity was less than 20%.

Som-Prakash and Saharan (2002) evaluated of three sprays of 0.1% karathane [dinocap] significantly reduced powdery mildew incidence of fenugreek up to 28% and increased grain yield by 20-50%.

Banyal and Rana (2003) evaluated fungicides individually and in combination against powdery mildew of pea and reported that single spray of bayleton or contaf followed by 2 or 3 sprays of karathane gave significantly effective control of powdery mildew. Cost : benefit ratio for contaf was found to be more. Hence, it was more economical fungicide.

Dange *et al.* (2003) studied that significantly least powdery mildew intensity of 22.4% was recorded in sulphur dust @ 25 kg/ha which was closely followed by 0.4% wettable sulphur (25.6%). The best fungicides were 0.005%

hexaconazole (26.3%), 0.02% tridimefon (28.4%) and 0.005% penconazole (29.8%) in reducing the disease in fenugreek.

Gupta and Sharma (2003) evaluated efficacy of some EBI (Ergosterol Biosynthesis Inhibitor) fungicides against powdery mildew of pea and reported that all the fungicides significantly reduced the disease severity. However, fungicide orius (Tebuconazole) (0.06%) followed by bayleton (Triadimefon) (0.1%), contaf (Hexaconazole) (0.05%) and karathane (Dinocap) (0.05%) significantly reduced the disease severity with maximum green pod yield.

Singh (2003) revealed that the sprays of bayleton (0.05%) and (0.025%) were found most effective for better management of powdery mildew disease intensity together with higher grain yield in fenugreek. Karathane (0.1%) was next best in order of efficacy and at par with sulphur dust.

Kunkalika and Padaganur (2004) reported that tridemorph was found to be effective in reducing the powdery mildew disease of green gram spread with the effect from first spray.

Solanki (2004) studied that two sprays of bayleton @ 0.1% at an interval of 15 days was found most effective in reducing the disease and increasing the seed yield in both the crop years followed by karathane L.C. (0.1%), calixin (0.1%) and sultaf (0.2%) in fenugreek. The highest cost benefit ratio was recorded from sultaf treated plots followed by sulphur dust and karathane.

Singh (2007) evaluated seven fungicides against powdery mildew, rust and *Ascochyta* blight of pea under field conditions. Two years pooled data revealed that two sprays of hexaconazole 5 EC @ 0.2% resulted in good control of powdery mildew.

Singh and Tomar (2007) revealed that carbendazim as soil drench and spray 0.1% after 60 days and wettable sulphur used as spray (0.2%) after 60 days were found significantly superior with low per cent disease intensity of 25.5, 25.2 during 2004-05 and 20.8, 20.2 during 2005-06, respectively in comparison to control (78.7) in coriander.

Surwase *et al.* (2009) studied that two to three sprayings of either of the fungicide hexaconazole (0.05%), penconazole(0.05%), tridemorph (0.04%) or

carbendazim (0.025%) were found most effective in controlling the powdery mildew disease and giving better seed yield in pea.

Suryawanshi *et al.* (2009) studied that karathane 48 EC (0.1%) was most effective, recording least mean powdery mildew intensity (15.14%) and highest grain yield (1425kg/ha) and test weight (58.00g) in mungbean crop. Considering cost: benefit ratio the most economical treatment was sulfex (1:2).

Akbari and Parakhia (2010) reported that the minimum disease intensity of 23.97% was recorded in coriander with three sprays of propiconazole (0.025%) closely followed by difenconazole (0.025%) and tridemefon where 26.15, 30.18 and 30.56 % were recorded, respectively.

Khunti *et al.* (2010) reported that significantly minimum disease intensity of 3 to 13% with average 7.63% was recorded in the treatment of hexaconazole 0.005% during all the four (2002, 2004, 2006 and 2007) years as well as in pooled data and it was at par with carbendazim 0.05% in which 3.5 to 15% with average 9.5% disease intensity was recorded. Thus hexaconazole 0.005% and carbendazim 0.05% found most effective and equivalent for control of powdery mildew in black gram.

Kachhot (2011) studied that minimum disease, maximum disease control and maximum green pod yield were obtained by hexaconazole 5EC, tridemefon 25WP and triflumizole 480SC.

Rankhode *et al.* (2011) studied that among tested fungicides against powdery mildew of green gram, 0.05% tridemorph recorded highest (85.11%) inhibition spore germination *in vitro* followed by plant extract 5% *Terminalia belerica* (66.45%) and culture filtrate of *Pseudomonas fluorescens* (63.93%). Maximum disease reduction (69.11%) was obtained in tridemorph and difenconazole applied @ 0.05% and 0.1%, respectively.

Vikas and Ratnoo (2011) reported that maximum yield (2023.35 kg/ha) was recorded with minimum per cent disease index (0.33%) in dinocap followed by sulphur dust yield (1973.12 kg/ha) with 0.68 per cent disease index in fenugreek.

Adinarayana (2012) reported that penconazole 10EC (NS) at 1.0 ml/L was found significantly superior followed by penconazole 10EC (NS) at 0.6 ml/L with low disease incidence of powdery mildew in blackgram.

Jagtap and Khalikar (2012) studied that the fungicide bayleton (0.05%) showed significantly lowest disease severity (15.93%) with maximum (26.87%) disease control. On the basis of effectiveness in controlling the powdery mildew disease of pea; the most effective fungicide recorded in the order of merit were bayleton (0.01%), tridemorph (0.05%) and dinocarp (0.05%), respectively.

Nargund *et al.* (2012) revealed that in green gram the least PDI was noticed with myclobutanil which was on par with propiconazole and carbendizim at 0.05% per cent was also found to be effective for two consecutive years.

Adinarayana (2013) reported that taqat 75 WP at both concentrations of 500g and 750 g/ha as well as karathene 48 EC at 500ml/ha were highly effective in controlling the incidence of foliar fungal diseases, such as powdery mildew and rust in black gram.

Basandrai *et al.* (2013) reported that the least mean powdery mildew severity (0.05%) was recorded in black gram with three sprays of propiconazole followed by tebuconazole 250 EWF (2.2%) and hexaconazole 5EC (26.1%)

Hiremath (2013) studied that among all treatments, systemic fungicides such as propiconazole (0.1%) and carbendazim (0.1%) reduced the pea powdery mildew intensity and leaves become disease free.

Jarial *et al.* (2013) studied that plots sprayed with hexaconazole exhibited minimum pooled disease severity (35.50 and 16.50%, respectively) and maximum disease control (63.95 and 81.03%, respectively) both under natural and protected conditions during both 2010 and 2011 cropping seasons in pea.

2.6 Management with bioagents and botanicals

Pea cultivation all over the country including Marathwada region of Maharashtra state has been experiencing the serious menace of powdery mildew incidence. Most of the pea cultivars presently under cultivation are highly susceptible to the disease. Therefore, the biological agents and botanicals are the control measures

appears to be as suitable alternative for the management of powdery mildew using as protective and curative measures. The literature available on the bioagents and botanical extracts i.e. management of the powdery mildews of mungbean, urdbean and peas in particular and of other crops in general is being reviewed here in the following paragraphs.

Singh *et al.* (1991) studied ginger (*Zingiber officinale*) rhizome extract, (fresh and stored at 5 and 15°C for 1 month) at 10000, 15000 and 20000 ppm was used to control powdery mildew (caused by *Erysiphe pisi*) of peas. The highest dose of the fresh extract gave the best control.

Rettinassababady *et al.* (2000) evaluated three neem extracts (neem seed kernel extracts, neem oil and neem cake extract), leaf extracts of *Prosopis juliflora* and *Ipomoea carnea* leaf extracts against *E. polygoni* in black gram (*Vigna mungo*) in a pot culture experiment. Among the plant extracts, Neem seed kernel extract (5%) was most efficient in disease control and yield improvement.

Singh (2000) studied effect of neemazal (a product of Neem) against powdery mildew of pea and reported that neemazal could induce disease resistance in pea through hypersensitive reaction and also reported increased levels of proteins in leaves leading to the induction of resistance against powdery mildew in pea.

Kumar and Gupta (2008) reported that no powdery mildew infection in fly-ash based rhizobial application treatment was recorded whereas its incidence in all other treatments in adjacent crop rows ranged from 90 – 100 per cent in pea.

Shailbala and Khulbe (2009) revealed that soap nut performed significantly superior over other treatments in controlling the pea powdery mildew disease followed by pyrite.

Surwase *et al.* (2009) studied that among the botanicals, NSKE (@ 5%) was found most effective and economical with C:B ratio of 1:5.75. This was followed by ghaneri (10%) and garlic (10%) which were on par with C:B ratio, respectively of 1:4.84 and 1:4.12 and among the bioagents tested *V. lecani* @ 0.5% and *T. harzianum* @ 0.5% were found effective with C:B ratio in the range of 1:1.89 to 1:2.60.

Chhata *et al.* (2010) reported that soil application of neemcake + seed treatment with *Trichoderma* @ 8 kg/ha + foliar spray of neem formulation

(azadirachtin) found effective for organic pest and disease management module for fenugreek. Powdery mildew was observed at minimum level i.e. 21.45 and 26.78% at 70 and 100 DAS, respectively.

Kachhot (2011) studied that azadirachtin was better than turmeric powder to control the powdery mildew of pea.

Rankhode (2011) studied that among plant extracts, maximum (57.22%) disease reduction was observed in behada and the bioagent *P. fluorescens* filtrate showed 51.22% reduction of powdery mildew in green gram under field condition.

Sharma and Jat (2011) revealed that in pea crop minimum powdery mildew intensity (26.22%) with corresponding maximum pod yield (98.10 q/ha) was observed in seed treatment with *T. viride* (10g/ha) and two sprays of neem oil (0.3%).

Vikas and Ratnoo (2011) reported that the minimum conidial germination recorded at 500 ppm both in azadirachtin (47.70%) and neem oil (42.80%) followed by concentration of 250 ppm and 100 ppm of both these phytoextract for powdery mildew of fenugreek.

Jagtap and Khalikar (2012) studied that lowest disease severity was observed with *Trichoderma hamatum* followed by *Trichoderma viride* and *Pseudomonas fluorescens* against powdery mildew of pea.

2.7 Effect of sowing dates

By adjusting sowing dates of pea one can avoid the susceptible stage of the crop to the powdery mildew disease, which is an obviously good strategy. The literature available on the effect of sowing dates and varieties on the intensity/incidence of powdery mildew in pea is being reviewed here in following paragraphs.

Sharma (1992) reported that field peas sown in the month of January experienced the low levels of powdery mildew intensity than those sown in the month of March.

Effect of different sowing dates on the intensity and severity of powdery mildew (*Erysiphe polygoni* DC) on pea were studied and recorded by several workers. They reported that pea sown during first fortnight of September to second fortnight of October (early sowing) recorded minimum disease intensity than the crop

sown late in month of November and later (Wanjari and Raut, 1994 and Singh *et al.*, 1995).

Kumari and Prasad (1998) studied 4 different sowing dates (15th October, 5th November, 21st November and 6th December). Out of these, 15th October sowing date was the most suitable for sowing pea cultivars as the intensity of powdery mildew disease, caused by *Erysiphe polygoni*, was low and the yield was higher compared with the other dates.

Sharma and Sharma (2002) studied influence of sowing dates and spacing on powdery mildew intensity/severity and seed yield in pea (Cv. Arkel) and reported that disease intensity and severity increased with delayed sowing of the crop with decreased seed yield.

Singh *et al.* (2002) studied effect of sowing dates and varieties on powdery mildew severity and yield of field pea and reported significantly higher disease severity in late sown crop (10th Nov.) than the early sown crop (30th Oct.) with highest seed yield (1230.40 kg/ha).

Magar *et al.* (2010) studied that the effect of sowing dates and pea varieties on incidence, intensity of powdery mildew (*Erysiphe polygoni* DC) and reported that -significantly least mean per cent disease incidence and intensity were recorded in the crop sown on 1st October, which was followed by the crop sown on 15th October. Comparatively higher disease incidence and intensity were recorded in the crop sown late during November. Thus early sown crop (1st October and 15th October) was suffered with least powdery mildew disease incidence and intensity and given highest seed yield than the crop sown late during November.

Surwase and Suryawanshi (2013) reported that pea crop sown during first and second fortnight of October was found to exhibit comparatively minimum powdery mildew intensity than the crop sown late during first and second fortnight of November.

2.8 Varietal screening

Most of the pea cultivars/varieties presently under cultivation has been found to be prone and highly susceptible to the powdery mildew disease. None of the

variety/cultivar has been reported to be completely resistant/tolerant to powdery mildew. Therefore, the screening of available cultivars, varieties, genotypes and germplasm lines of pea against powdery mildew will be helpful in the identification and location of the resistant/tolerant sources to powdery mildew, if any. Here in following paragraphs the work done on screening of pea crop against powdery mildew is being reviewed.

Saharan and Gupta (1983) revealed that out of 40 promising cultivars screened for source of resistance against powdery mildew of pea only P388 cultivar showed resistance. The cultivars, T10 and P185 were scored as moderately resistant and others as moderately susceptible to highly susceptible.

Thakur *et al.* (1988) screened 70 cultivars of pea against powdery mildew during the year 1984 and 1985 to find out stable sources of resistance. The cultivar HFP-6 was highly resistant. Six varieties viz., Rachana, PMR-332, JP-501, PMR-334, PMR-333 and Lahaul Spiti Local were moderately resistant. Cultivar Arkel was reported as highly susceptible.

Mathur *et al.* (1991) studied that out of 85 varieties of pea tested, 11 performed as resistant, 18 moderately resistant and rest of the varieties were either susceptible or highly susceptible.

Thakur *et al.* (1996) evaluated 86 pea lines for resistance to powdery mildew. Seven lines were observed under the disease score of 1-3 (<10% infection) and categorized as resistant whereas, other fourteen were rated as moderately resistant having a disease score of 5 (<25% infection).

Kazmi *et al.* (2002) studied that Rondo was highly susceptible variety for powdery mildew of pea with pronounced symptoms on the leaves, stems and pods.

Champawat *et al.* (2003) studied that out of 7 varieties HUP-3 and HUP-4 exhibited minimum infection of powdery mildew of pea while, Azad P-1 exhibited highest infection.

Hamidullah *et al.* (2007) evaluated ten advanced pea lines along with two commercial cultivars against powdery mildew (*Erysiphe polygoni*). Five test

entries i.e. PS-810106, PS-310396, PS-310539, PS-210377 and PS-110028 were resistant, one tolerant (PS-210246) and the rest were susceptible to the disease..

Hooda *et al.* (2010) reported that out of the 143 entries evaluated for resistance against powdery mildew, VP 233 and JP 15 of garden pea were found highly resistant (HR) whereas, JP 585, DP 9411, DPP 9418-06, PMR 1, FC 2, VRPMR 9, DPP 4, and VPPMR 11 exhibited a resistant reaction (R). No entry of field pea showed either HR or R reaction against the disease. FC 1, NDVP 250, DVP 1, FCS 1, PMR 3, PMR 4 and VPPMSN 9 of garden pea and VL 47 of field pea were rated moderately resistant. DPP 4, PMR 2, VP 9211, VP 7830 and P 185 were found moderately susceptible to *Erysiphe polygoni*. Rest of the entries were found susceptible to highly susceptible. Thus, VP 233 and JP 15 genotypes of garden pea can be exploited for developing resistant genotypes against the disease.

Muhammad *et al.* (2010) reported that out of eight, four test entries were found resistant, one moderately resistant and three were susceptible for powdery mildew of pea. The lines, 26713 and 27315 showed maximum resistance to the disease while, the line 27313 was the most susceptible. The lines 27310 and 26719, excelled in pods plant⁻¹ and grains pod⁻¹, respectively. Maximum vegetative growth of the tendrils was exhibited by the lines 27313 and 26713.

Azmat *et al.* (2012) studied that One hundred forty-six pea accessions, collected from different countries, were screened against powdery mildew. It was determined that accessions 9057, 9370, 9375, 10609, 10612, 18293, 18412, 19598, 19611, 19616, 19727, 19750, 19782, 20126, 20152, 20171, It-96, No. 267, and No. 380 were resistant; accessions It-96 and No. 267 were highly resistant.

Kapoor and Gopi (2013) evaluated fifteen field pea lines for six yield related characters and reaction to powdery mildew disease under natural epiphytotic conditions. Results showed that the disease severity among the different lines ranged from 0 to 69.75%. Lines, F10-131, F10-139, F10-127, F10-136, F10-140, F10-142 and F10-121 showed immune reaction with no observable disease symptoms.

Rana *et al.* (2013) screened 701 accessions of garden and field pea against powdery mildew disease under natural epiphytotic conditions and 64 accessions found resistant.

Sharma and Sharma (2013) revealed that three genotypes VP-233, PMVAR-1 and PRP-801 exhibited scattered lesions on second set of leaves which were classified as resistant category under 2 scale. These genotypes exhibited minimum percent disease index (PDI) which ranged from 2.22 to 4.44. Four varieties viz., VP-433, DARL- 404, Arkel and VL-7 were also found susceptible, with higher PDI ranging from 62.21 to 69.21. Lines DARL-405 and KS-257 were recorded as highly susceptible to powdery mildew of pea at scoring reaction of 9, which exhibited maximum PDI value 89.91 to 94.91.



MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present investigations were carried out during *Rabi*-2013. All the field experiments conducted at Department of Plant Pathology, College of Agriculture, Latur. The details of the materials used and methods followed in the present studies on powdery mildew of pea are described herein following paragraphs.

3.1 Materials

3.1.1 Seeds

Seeds of the pea varieties/cultivars required for the experimental work were obtained from Saswad market, Tahsil Purandar, district Pune and local market, Latur.

3.1.2 Fungicides

The following fungicides with their recommended doses were used during present study. The fungicides required for the experimental work were obtained from local market, Latur.

Sr. No	Common name	Trade name	Con. Used	Cost (Rs.)	Manufacturer
1	Carbendazim	Bavistin 50WP	0.1%	63/50 gm	BASF India Ltd., Mumbai
2	Wettable sulphur	Thiovit 80 WP	0.3%	80/500 gm	Syngenta India Ltd., Mumbai
3	Chlorothalonil	Kavach 75 WP	0.2%	1040/kg	Syngenta India Ltd., Mumbai
4	Propiconazole	Tilt 25 EC	0.1%	1400/kg	Syngenta India Ltd., Mumbai
5	Hexaconazole	Contaf 5 EC	0.1%	600/lit	Rallis India Ltd., Mumbai

6	Thiophanate methyl	Roko 70 WP	0.1%	341/250 gm	Biostadt India Ltd., Mumbai
7	Azoxystrobin	Amistar 23 SC	0.02%	320/50 ml	Syngenta India Ltd., Mumbai
8	Difenconazole	Score 25 EC	0.05%	3500/kg	Syngenta India Ltd., Mumbai
9	Captan+Hexaconazole	Taqat 75 WP	0.1%	128/100 gm	Rallis India Ltd., Mumbai

3.1.3 Bioagents

The following bioagents with their recommended doses were used for present study. The bioagents required for the experimental work were obtained from Department of Plant Pathology, College of Agriculture, Parbhani, V.N. M. K. V., Parbhani.

Sr. No	Bioagens	Con. used	Cost (Rs/kg)
1	<i>Trichoderma viride</i>	0.4%	100
2	<i>Verticillium lecani</i>	0.4%	100
3	<i>Pseudomonas fluorescens</i>	0.4%	100
4	<i>Metarrhizium anisopliae.</i>	0.4%	100

3.1.4 Botanicals

The following botanicals reported to be exhibited antifungal properties against fungal pathogens were collected from farms of College of Agriculture, Latur and local market of Latur and following botanicals with their doses were used.

Sr. No	Bioagent	Con. used	Cost (Rs/kg)
1	Neem (<i>Azadirachta indica</i>)	10%	-
2	Ginger (<i>Zingiber officinale</i>)	5%	100
3	Beshram (<i>Ipomea carnea</i>)	10%	-
4	Nirgudi (<i>Vitex negundo</i>)	10%	-
5	Menthol (<i>Mentha arvensis</i>)	10%	100

3.1.5 Miscellaneous

Miscellaneous experimental materials viz., measuring tape, wooden sticks, nylon rope, labels, tags, paper/cloth bags, research microscope, sprayer, measuring cylinder, bucket, Petri plates, glass slide, cover slips, needle, staple, polythene bags, weighing balance, funnel, pipettes, forceps, filter paper, blotter paper, sieve, etc. were obtained from the Department of Plant Pathology, College of Agriculture, Latur.

3.2 Methodology

3.2.1 Management of powdery mildew of pea with newer fungicides

a) Experimental site

The experiment was conducted during *Rabi*, 2013 on the experimental farm of the Department of Plant Pathology, College of Agriculture, Latur.

The field experiment was laid out by applying randomized block design with 10 treatments and three replications. The pea variety, AP-3, susceptible to powdery mildew (*Erysiphe polygoni* DC.) was used during present experiment. Recommended dose of fertilizers was applied and irrigated lightly for better seed germination. Ten days after sowing, thinning and gap filling operations were done to maintain uniform plant population. Experimental plots were frequently visited and keenly observed recording observation of the disease symptoms, if any. Intercultural operations were performed as and when required.

b) Experimental details

Season	:	<i>Rabi</i> -2013
Variety	:	AP-3
Plot size	:	Gross: 2.40x1.80m ² Net : 2.10x1.70m ²
Spacing	:	30x10cm ² .
Design	:	Randomized block design
Replications	:	Three
Treatments	:	Ten

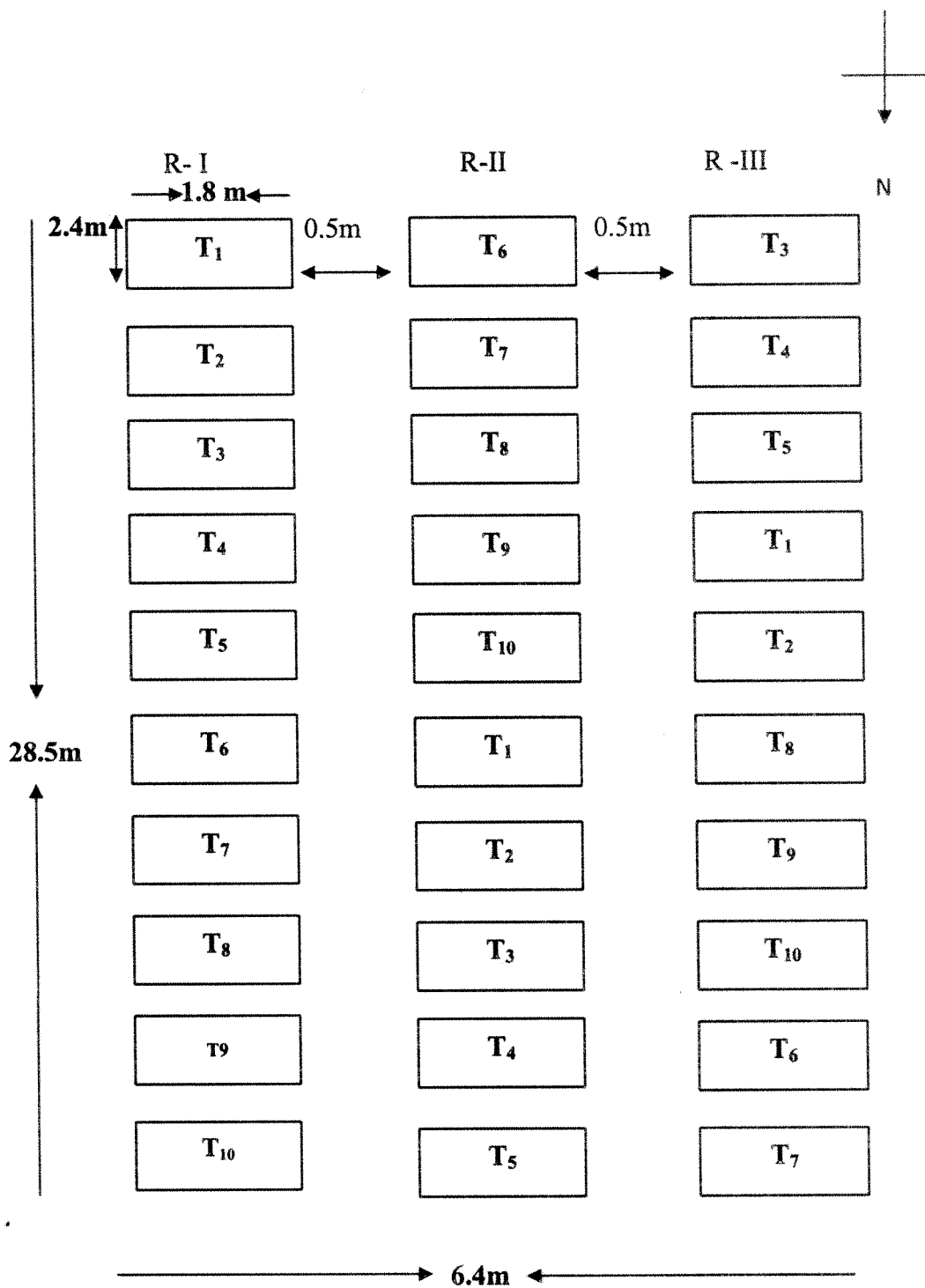


Fig.1. Plan and layout of field experiment on effect of fungicides on powdery mildew of pea Cv. AP-3

c) Treatment details:

- T₁ : Bavistin (Carbendazim 50 WP) 0.1%
- T₂ : Thiovit (Wettable sulphur 80 WP) 0.3%
- T₃ : Kavach (Chlorothalonil 75WP) 0.2%
- T₄ : Tilt (Propiconazole 25 EC) 0.1%
- T₅ : Contaf (Hexaconazole 5EC) 0.1%
- T₆ : Roko (Thiophanate methyl 70WP) 0.1%
- T₇ : Amistar (Azoxystrobin 23SC) 0.02%
- T₈ : Score (Difenconazole 25EC) 0.05%
- T₉ : Taqat (Captan 70 WP+ Hexaconazole 5WP) 0.1%
- T₁₀ : Control (Water spray)

Three sprayings of fungicides were given at ten days interval. First spraying was done after disease initiation and subsequent second and third sprayings were given with 10 days intervals.

d) Observations

The observations on disease incidence were taken after disease appearance and at 3rd, 5th, 7th and 10th day after each spraying.

Observations on powdery mildew disease severity were recorded on five randomly selected plants from the two each bottom, middle and top leaves. The first observations were taken after disease appearance and subsequent three observations were taken 10th day after each spraying. The powdery mildew disease was graded on the basis of disease severity observed on leaves by applying 0-9 disease rating scale developed by Mayee and Datar (1986).

Based on numerical ratings observed, per cent disease severity was calculated by applying the formula as given below:

$$\text{PDS} = \frac{\text{Summation of numerical ratings}}{\text{No. of leaves/plants observed} \times \text{maximum rating}} \times 100$$

Further, per cent disease control (PDC) was worked out by applying the formula:

$$\text{PDC} = \frac{\text{PDI in control plot} - \text{PDI in treatment plot}}{\text{PDI in control plot}} \times 100$$

Disease incidence will be worked out by following formula

$$\text{Disease incidence \%} = \frac{\text{No. of infected plant observed}}{\text{Total no. of plants observed}} \times 100$$

Matured and dried pods of pea were harvested after last observation.

The pods were harvested separately treatmentwise and grain yield were recorded and finally the grain yield data was presented on hectare basis.

3.2.2 Management of powdery mildew of pea with botanicals and bioagents

a) Experimental site

The experiment was conducted during *Rabi*, 2013 on the experimental farm of the Department of Plant Pathology, College of Agriculture, Latur.

The field experiment was laid out by applying randomized block design with 10 treatments in three replications and by using variety, AP-3, susceptible to powdery mildew (*Erysiphe polygoni* DC.). Recommended dose of fertilizers was applied and irrigated lightly for better seed germination. Ten days after sowing, thinning and gap filling operations were done to maintain uniform plant population. Experimental plots were frequently visited and keenly observed for recording observation of the disease symptoms, if any. Intercultural operations were performed as and when required.

b) Experimental details

Season	:	<i>Rabi</i> -2013
Variety	:	AP-3
Plot size	:	Gross: 2.40x1.80m ²
	:	Net : 2.10x1.70m ²
Spacing	:	30x10cm ² .

Design	: Randomized block design
Replications	: Three
Treatments	: Ten

c) Treatment details:

- T₁ : Neem leaf extract 10%
- T₂ : Ginger extract 5%
- T₃ : *Ipomea* leaf extract 10%
- T₄ : Nirgudi (*Vitex negundo*) 10%
- T₅ : Menthol (*Mentha arvensis*) 10%
- T₆ : *Pseudomonas fluorescens* 0.4%
- T₇ : *Trichoderma viride* 0.4%
- T₈ : *Metarrhizium anisopliae*. 0.4%
- T₉ : *Verticillium lecani* 0.4%
- T₁₀ : Control (Water spray)

Three sprayings of botanicals and bioagents were given at ten days interval. First spraying was done after disease initiation and subsequent second and third sprayings were given with 10 days interval.

d) Observations

The observations on disease incidence were taken after disease appearance and at 3rd, 5th, 7th and 10th day after each spraying.

Observations on powdery mildew disease severity were recorded on five randomly selected plants from the two each bottom, middle and top leaves. The first observation was taken after disease appearance and subsequent three observations were taken 10th day after each spraying and per cent disease control was worked out. The powdery mildew disease was graded on the basis of disease severity observed on leaves by applying 0-9 disease rating scale developed by Mayee and Datar (1986).

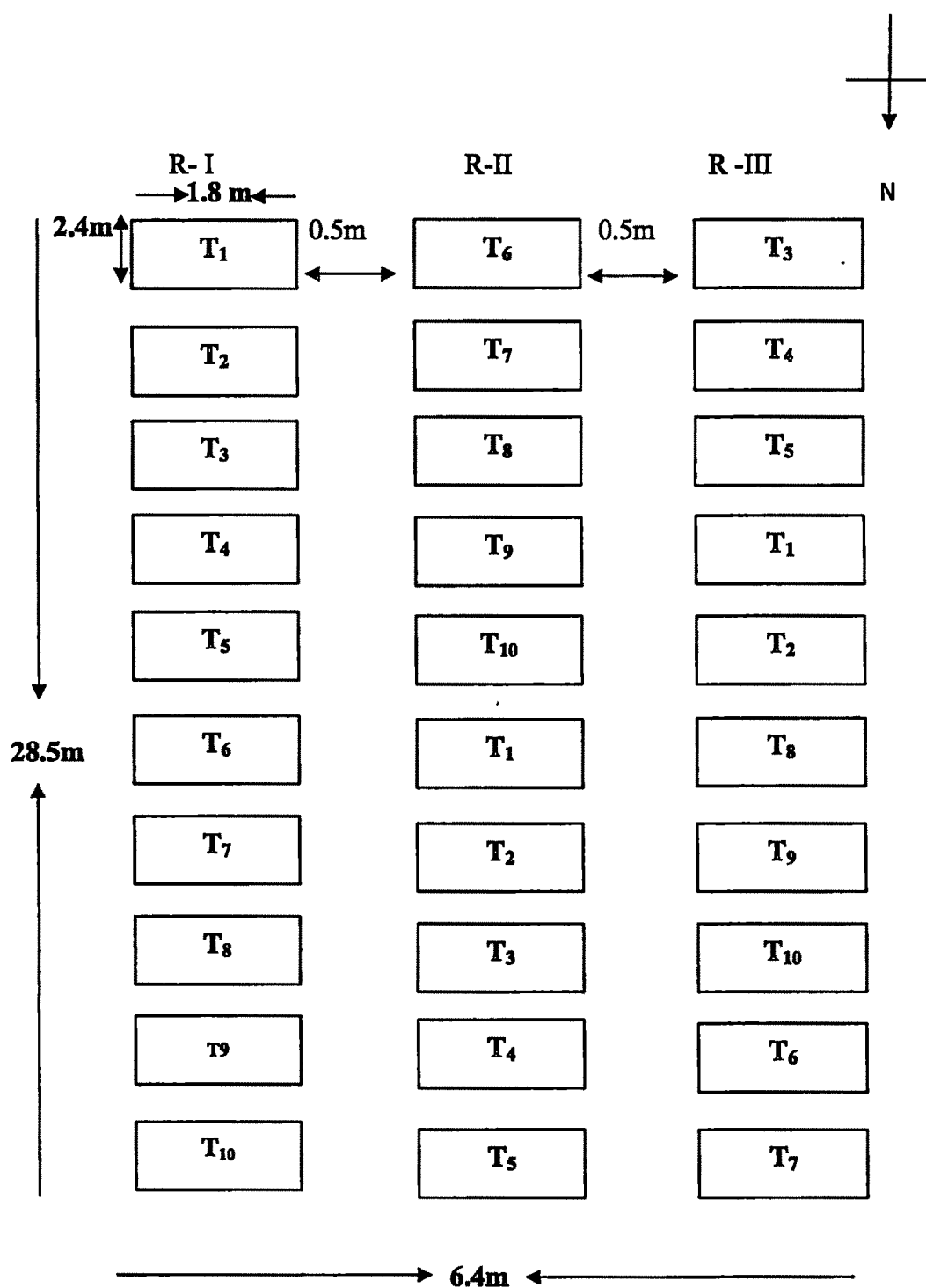


Fig.2. Plan and layout of field experiment on effect of botanicals and bioagents on powdery mildew of pea Cv. AP-3

Based on numerical rating observed, per cent disease severity was calculated and further per cent disease control (PDC) was worked out.

Matured and dried pods of pea were harvested after last observation. The pods were harvested separately treatmentwise and grain yield were recorded and finally the grain yield data was presented on hectare basis.

3.2.3 Cultivar/variety screening for powdery mildew of pea.

A total of 7 cultivars/ varieties of pea were screened for their reactions against powdery mildew disease under natural epiphytotics. The experiment was conducted during *Rabi*, 2013 on research farm of the Department of Plant Pathology, College of Agriculture, Latur. All recommended cultural practices were followed. The observations on disease severity and disease incidence recorded at seven days interval from disease appearance. Observations recorded on number of pods per plant on five labeled plants and averaged and also number of grains per pod were counted in five randomly selected pods and then averaged. The powdery mildew disease was graded on the basis of disease intensity observed on leaves by applying 0-9 disease rating scale developed by Mayee and Datar (1986) as described below and also presented in PLATE I. Based on per cent mean PDI, test varieties/cultivars were categorized as: Immune (0 PDI), Resistant (1-10 PDI), moderately resistant (11-25 PDI), moderately susceptible (26-50 PDI), susceptible (51-75 PDI) and highly susceptible (>76 PDI).

Grade/Scale Description

- | | |
|---|---|
| 0 | = No symptoms of powdery mildew on leaves |
| 1 | = Small powdery specks covering 1% or less leaf area |
| 3 | = Powdery lesions (small up to 5mm in size) covering 1-10% of leaf area |
| 5 | = Powdery lesions enlarging covering 11-25% of leaf area |
| 7 | = Powdery lesions coalesce to form big patches covering 26-50% of leaf area |
| 9 | = Big powdery patches covering 51% of leaf area. Lesions also produced on pod and tendrils. |



0 Scale



1 Scale



3 Scale



5 Scale



7 Scale



9 Scale

PLATE I. Disease rating scale for powdery mildew of pea

3.2.4 Statistical analysis

The data of various experiments obtained was statistically analyzed using standard method described by Panse and Sukhatme (1967). The standard error (SE) for disease severity, disease incidence and grain yield were calculated and critical difference (C.D.) at 5% level of significance was worked out. The per cent data was transformed to arc sine values before subjecting to statistical analysis.



RESULTS

CHAPTER IV

RESULTS

Present investigations were under taken during *Rabi*, 2013 with objectives of management of powdery mildew of pea with fungicides, botanicals and bioagents and varietal screening against powdery mildew of pea. Results obtained were presented here in following headlines.

4.1 Symptomatology

In field, first symptoms of powdery mildew were noticed at 35 days after sowing of pea crop. Subsequently symptoms of the disease were noticed on all the aerial plant parts including leaves, stems, branches, flowers and pods. The characteristic symptoms first appeared on older bottom leaves were round, whitish spots on the upper surface of the leaves (PLATE II a) and later which spread on the lower surface of the leaves (PLATE II b). Whitish powdery spots of the disease further increased in number, enlarged and coalesced to form big whitish blotches covering entire leaf surface (PLATE II c). The heavily infected plants exhibited apparently talcum powder like appearance from the outside. As the disease advanced, the white or dirty white colour of the spots changed grayish, brown coloured and the affected leaves turned pale yellow or brown, curl and became wrinkled.

Such bottom leaves later get dried and defoliated. Such whitish spot was also observed on stem, branches and pods (PLATE III). Heavily infected leaves showed the blightening effect and pods get shrivelled which eventually dried leading to improper seed setting, reduction in seed number, seed size and seed weight.

Microphotographs of oidia/spores taken from typical symptoms observed from naturally infected plants and presented in PLATE IV.

4.2 Management with fungicides

Total nine fungicides were evaluated under field condition against powdery mildew of pea using susceptible variety AP-3 during *Rabi*, 2013 (PLATE V). Results obtained in respect of disease incidence, severity, per cent disease control, seed yield and cost: benefit ratio are presented here in following paragraphs.



a) Whitish spots on upper surface of leaves



b) Symptoms on lower surface of leaves



c) Symptoms covering entire leaf surface

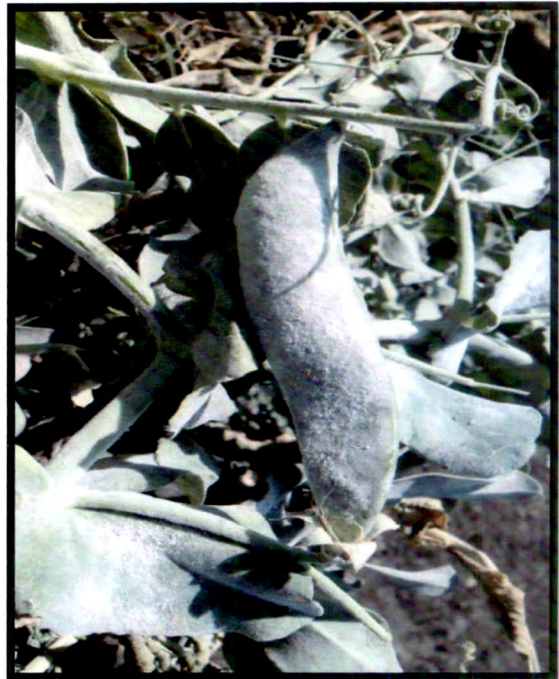
PLATE II. Symptoms of powdery mildew on leaf



a) On stem

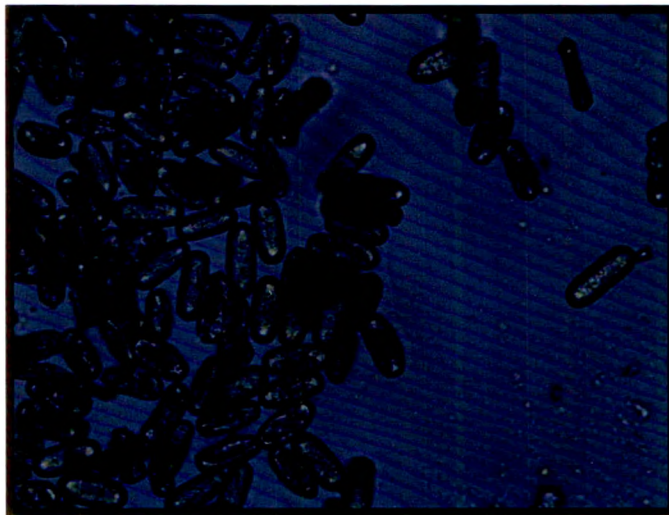
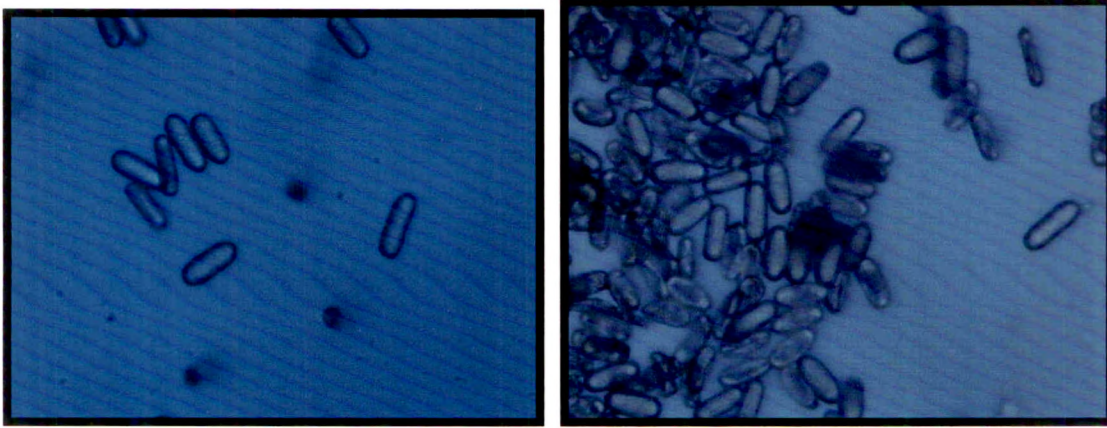


b) On branches

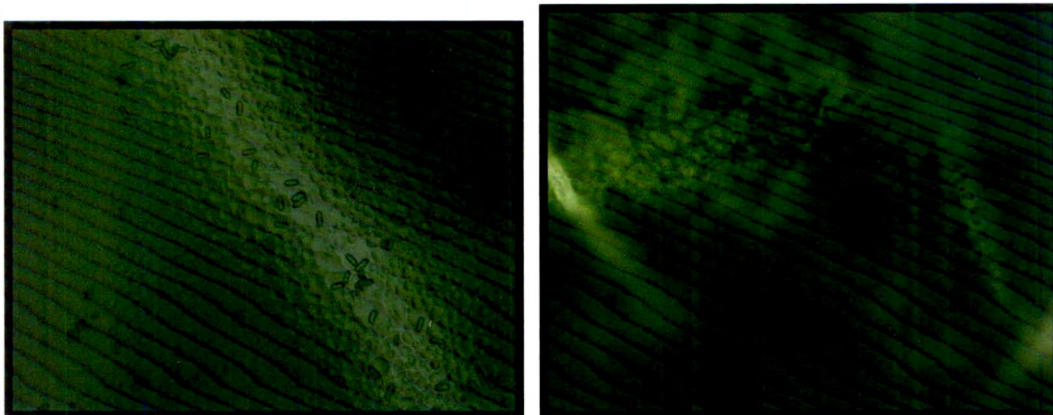


c) On pod

PLATE III. Symptoms of powdery mildew on pods and other parts of pea plant



a) Spores observed on slide



b) Spores observed directly on leaf

PLATE IV. Microphotographs showing typical spores of *Erysiphe polygoni* causing powdery mildew of pea



**PLATE V. Field view of an experiment on effect of fungicides
against powdery mildew of pea Cv. AP-3**

4.2.1 Effect of fungicides on powdery mildew incidence

To study the effect of fungicides on powdery mildew incidence an experiment was carried out and results obtained were presented in Table. 1 and graphically depicted in Fig. 3. Results revealed that all the fungicides were found effective and significantly reduced the powdery mildew incidence over control.

**Table 1. Effect of fungicides on powdery mildew disease incidence in pea
Cv. AP-3**

Sr. no	Treatments	Disease incidence (%)				
		Before spraying	After first spraying	After second spraying	After third spraying	Mean
1	T ₁ - Carbendazim (0.1%)	12.38 (20.60)	37.73 (37.89)	32.07 (34.49)	21.60 (27.69)	25.94 (30.62)
2	T ₂ - Wettable sulphur (0.3%)	12.81 (20.97)	33.04 (35.09)	29.51 (32.90)	19.58 (26.26)	23.75 (29.16)
3	T ₃ - Chlorothalonil (0.2%)	15.50 (23.19)	36.59 (37.22)	25.06 (30.04)	20.63 (27.01)	24.44 (29.63)
4	T ₄ - Propiconazole (0.1%)	16.80 (24.20)	27.07 (31.35)	21.51 (27.63)	15.8 (23.42)	20.29 (26.77)
5	T ₅ - Hexaconazole (0.1%)	17.47 (24.71))	25.49 (30.32)	19.26 (26.03)	13.91 (21.90)	19.03 (25.86)
6	T ₆ - Thiophanate Methyl (0.1%)	18.55 (25.51)	29.20 (32.71)	26.48 (30.97)	18.27 (25.30)	23.1 (28.72)
7	T ₇ - Azoxystrobin (0.02%)	18.90 (25.77)	28.62 (32.34)	24.28 (29.52)	16.35 (23.85)	22.07 (28.02)
8	T ₈ - Difenconazole (0.05%)	14.66 (22.51)	32.42 (34.70)	29.91 (33.16)	19.61 (26.28)	24.15 (29.43)
9	T ₉ - Captan+ Hexaconazole (0.1%)	17.01 (24.36)	29.97 (33.19)	25.51 (30.34)	17.13 (24.45)	22.40 (28.25)
10	T ₁₀ - Control (Water spray)	16.43 (23.90)	44.54 (41.86)	51.52 (45.87)	57.7 (49.43)	42.55 (40.71)
S. E ±		0.639	1.007	1.121	1.092	0.965
C.D at 5%		1.898	2.993	3.332	3.244	2.867

Figures in Parentheses are sine transform values

The powdery mildew disease incidence before spraying was ranged from 12.38% to 18.90% and average incidence was 16.08 %. The disease incidence was found to be increased after first spraying and it was ranged from 25.49 % to 44.54% (average 32.47%). After second and third spraying disease incidence was reduced and ranged from 19.26 % to 51.52 % (average 28.51 %) and 13.91 % to 57.7 % (average 22.06 %), respectively.

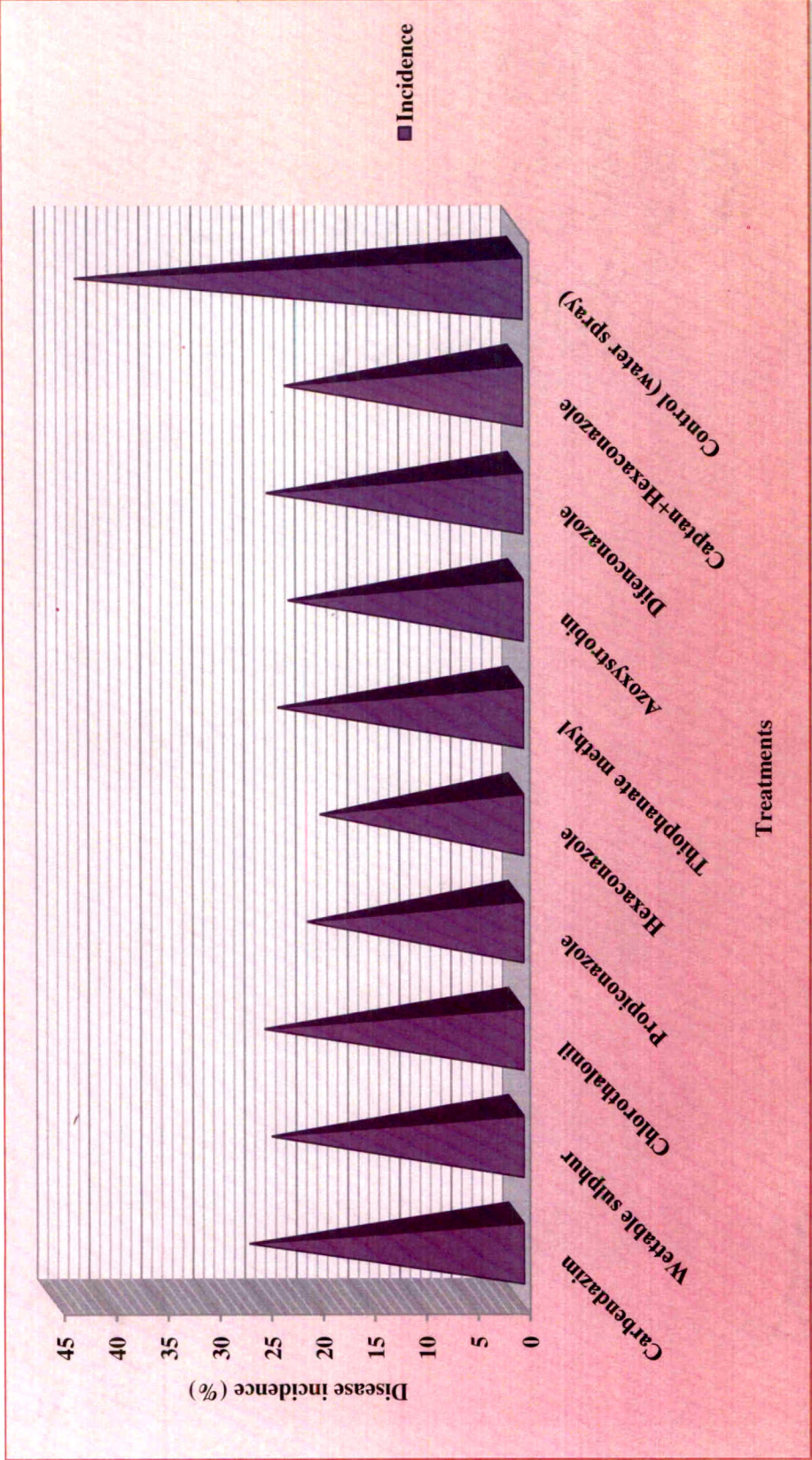


Fig. 3. Effect of fungicides on powdery mildew disease incidence of pea Cv. AP-3

The results revealed that after second and third spraying plot sprayed with Hexaconazole fungicide recorded least disease incidence 19.26 and 13.91 %, respectively and it was significantly superior over all other fungicide treatments. This treatment was at par with Propiconazole which recorded disease incidence 21.51 % and 15.8 % after second and third spray, respectively. The highest disease incidence was found in plot sprayed with Carbendazim i.e. 32.07% after second spray and 21.60 % after third spray. The plot sprayed with water exhibited disease incidence 51.52 % after second spray and 57.7 % after third spray, respectively.

Thus, from mean per cent disease incidence data indicated that all the treatments were significantly and gradually reduced the powdery mildew incidence after second and third sprayings over control. The mean disease incidence was ranged from 19.03 to 25.94%. However, the mean disease incidence indicate that spraying of Hexaconazole was found to be most effective with lowest mean disease incidence of 19.03% which was at par with Propiconazole (20.29%). The maximum per cent disease incidence was recorded in control (42.55%).

4.1.2 Effect of fungicides on powdery mildew disease severity

To study the effect of fungicides on powdery mildew severity an experiment was carried out and results obtained were presented in Table. 2 and graphically depicted in Fig. 4. Results revealed that all the fungicides were found effective and significantly reduced the powdery mildew severity over control.

Results showed that the powdery mildew severity observed before spraying was ranged from 6.37 to 9.63 %. Even after first spraying, per cent disease severity was more than before spraying. Disease severity recorded after first spraying was ranged from 19.26 to 28.89 % and average severity was 25.04 %, irrespective of treatments and control plot recorded 34.07% disease severity. After second and third spray, the per cent disease severity was decreased significantly as compared to first spraying.

After second spraying, the disease severity was ranged from 11.74 to 23.89 % and average severity was 19.96 %. The lowest disease severity was recorded from the plots sprayed with Hexaconazole (11.74%) which was at par with Propiconazole (14.38%) and this was also at par with Azoxystrobin (16.30%), Captan+Hexaconazole (17.04 %) and Thiophanate methyl (17.78 %) followed by

**Table 2. Effect of fungicides on powdery mildew disease severity in pea
Cv. AP-3.**

Sr. no	Treatments	Disease severity (%)					Per cent disease control
		Before Spraying	After first spraying	After second spraying	After third spraying	Mean	
1	T ₁ - Carbendazim (0.1%)	6.37 (14.62)	28.89 (32.51)	23.89 (29.26)	9.52 (17.98)	17.17 (24.48)	45.82
2	T ₂ - Wettable sulphur (0.3%)	7.20 (15.56)	26.67 (31.1)	19.32 (26.07)	8.39 (16.84)	15.39 (23.10)	51.43
3	T ₃ - Chlorothalonil (0.2%)	7.41 (15.8)	28.15 (32.04)	18.52 (25.49)	10.37 (18.78)	16.11 (23.66)	49.16
4	T ₄ - Propiconazole (0.1%)	8.20 (16.64)	20.74 (27.1)	14.38 (22.28)	7.39 (15.77)	12.68 (20.86)	59.99
5	T ₅ - Hexaconazole (0.1%)	8.89 (17.35)	19.26 (26.03)	11.74 (20.04)	6.13 (14.33)	11.50 (19.82)	63.71
6	T ₆ - Thiophanate Methyl (0.1%)	9.37 (17.82)	21.55 (27.66)	17.78 (24.94)	8.55 (17.00)	14.31 (22.23)	54.84
7	T ₇ - Azoxystrobin (0.02%)	9.63 (18.08)	21.48 (27.61)	16.30 (23.81)	7.70 (16.11)	13.78 (21.79)	56.52
8	T ₈ - Difenconazole (0.05%)	6.67 (14.97)	25.89 (30.58)	21.52 (27.64)	9.21 (17.66)	15.82 (23.44)	50.08
9	T ₉ - Captan+ Hexaconazole (0.1%)	8.40 (16.85)	23.70 (29.13)	17.04 (24.38)	7.91 (16.34)	14.26 (22.19)	55.00
10	T ₁₀ - Control (Water spray)	8.15 (16.59)	34.07 (35.71)	39.13 (38.72)	45.42 (42.37)	31.69 (34.26)	-
S. E±		1.826	1.477	1.231	0.736	1.317	-
C.D at 5%		NS	4.390	3.657	2.186	3.914	-

Figures in Parentheses are sine transform values

Chlorothalonil (18.52%), Wettable sulphur (19.32%), Difenconazole (21.52%) and Carbendazim (23.89%), respectively. The plot sprayed with water (control) exhibits maximum disease severity (39.13%).

Powdery mildew severity was after application of third spray ranged from 6.13 to 10.37%. The plot sprayed with Hexaconazole showed lowest per cent disease severity i.e. 6.13% which was at par with Propiconazole (7.39%), Azoxystrobin (7.70%) and Captan+Hexaconazole (7.91%) followed by Wettable sulphur (8.39%), Thiophanate methyl (8.55%), Difenconazole (9.21 %), Carbendazim (9.52%) and Chlorothalonil (10.37%), respectively. The plot sprayed with water (control) exhibited maximum disease severity (45.42%).

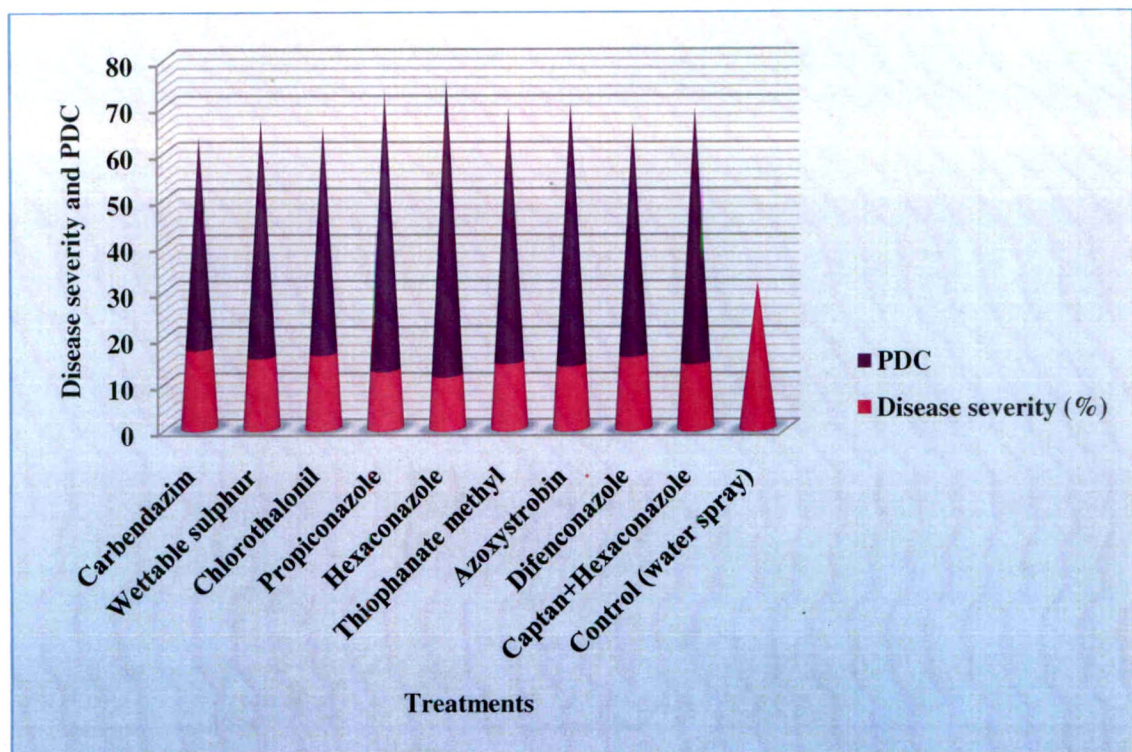


Fig. 4. Effect of fungicides on disease severity and per cent disease control of powdery mildew of pea Cv. AP-3

The mean powdery mildew disease severity in all treatments ranged from 11.50 to 31.69 per cent. The least mean powdery mildew disease severity was reported in Hexaconazole spraying treatment (11.50%) which was at par with Propiconazole (12.68 %), Azoxystrobin (13.78 %), Captan+Hexaconazole (14.26%), Thiophanate methyl (14.31%) and Wettable sulphur (15.39%) followed by Difenconazole (15.82%), Chlorothalonil (16.11%) and Carbendazim (17.17%), respectively. The plot sprayed with water (control) exhibited maximum disease severity (31.69%).

From mean per cent disease severity the per cent disease control over control treatment was calculated for all treatments and depicted in Table 2. Per cent disease control over control was ranged from 45.82 to 63.71 percent. The highest mean disease control of 63.71% was recorded by Hexaconazole. The second and third best treatments were Propiconazole (59.99%) and Azoxystrobin (56.52%). This was followed by Captan+Hexaconazole (55.00%), Thiophanate methyl (54.84%) and Wettable sulphur (51.43%), Difenconazole (50.08%), Chlorothalonil (49.16%) and Carbendazim (45.82%), respectively.

4.2.3 Effect on grain yield

The results presented in Table 3 graphically in Fig. 5 indicated that all the treatments, significantly reduced and effectively controlled the powdery mildew severity and increased the grain yield over control. The yield in respect of all treatments ranged from 9.96 to 13.84 qt/ha as against 8.04 qt/ha in control plot. Highest grain yield (13.84 qt/ha) with lowest disease severity (11.50%) was recorded with Hexaconazole. The second best fungicide Propiconazole recorded grain yield of 12.92 qt/ha with mean disease severity 12.68%. This was followed by Azoxystrobin (12.36 qt/ha and disease severity: 13.78%), Captan+Hexaconazole (11.61 qt/ha and disease severity: 14.26%), Thiophanate methyl (11.40 qt/ha and disease severity: 14.31%), Wettable sulphur (11.07 qt/ha and disease severity: 15.39%), Difenconazole (10.56 qt/ha and disease severity: 15.82%), Chlorothalonil (10.41 qt/ha and disease severity: 16.11%) and Carbendazim (9.96 qt/ha and disease severity: 17.17%), respectively.

Table 3. Effect of fungicides on powdery mildew of pea as affected by disease incidence, severity and yield in pea Cv. AP-3.

Sr. no	Treatments	Disease incidence (%)	Disease severity (%)	Per cent disease control	Yield (qt/ha)	% increase over control
1	T ₁ - Carbendazim (0.1%)	25.94 (30.62)	17.17 (24.48)	45.82	9.96	23.88
2	T ₂ - Wettable sulphur (0.3%)	23.75 (29.16)	15.39 (23.10)	51.43	11.07	37.69
3	T ₃ - Chlorothalonil (0.2%)	24.44 (29.63)	16.11 (23.66)	49.16	10.41	29.48
4	T ₄ - Propiconazole (0.1%)	20.29 (26.77)	12.68 (20.86)	59.99	12.92	60.70
5	T ₅ - Hexaconazole (0.1%)	19.03 (25.86)	11.50 (19.82)	63.71	13.84	67.66
6	T ₆ - Thiophanate Methyl (0.1%)	23.1 (28.72)	14.31 (22.23)	54.84	11.40	41.79
7	T ₇ - Azoxystrobin (0.02%)	22.07 (28.02)	13.78 (21.79)	56.52	12.36	53.73
8	T ₈ - Difenconazole (0.05%)	24.15 (29.43)	15.82 (23.44)	50.08	10.56	31.34
9	T ₉ - Captan+ Hexaconazole (0.1%)	22.40 (28.25)	14.26 (22.19)	55.00	11.61	44.40
10	T ₁₀ - Control (Water spray)	42.55 (40.71)	31.69 (34.26)	-	8.04	00.00
SE ±		0.965	1.317	-	0.606	-
CD at 5%		2.867	3.914	-	1.799	-

Figures in Parentheses are sine transform values

All the treatments significantly increased the grain yield over control (Table 3). The per cent increased in grain yield was ranged from 23.88 to 67.66%. However, highest per cent grain yield (67.66%) over control was recorded with Hexaconazole. The second best fungicide Propiconazole recorded increased grain yield of 60.70%. This was followed by Azoxystrobin (53.73%), Captan +Hexaconazole (44.40%), Thiophanate methyl (41.79%), Wettable sulphur (37.69%), Difenconazole (31.34%), Chlorothalonil (29.48%) and Carbendazim (23.88%), respectively.

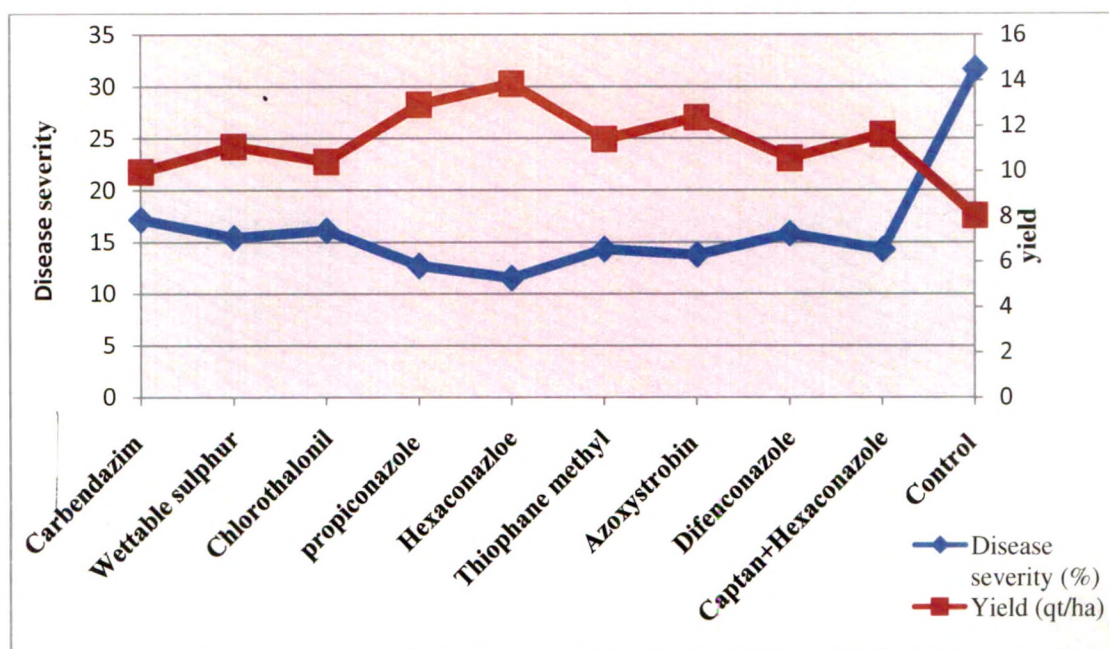


Fig. 5. Effect of fungicides on powdery mildew disease severity and yield of pea Cv. AP-3

4.2.4 Cost: Benefit ratio

Results obtained on economics/incremental cost benefit ratio (ICBR) in respect of various spray treatments presented in Table 4. Results revealed that the effect of fungicides on powdery mildew severity and thereby resulted in maximum seed yield, maximum gross and additional income over control and given significant cost benefit ratio.

All the treatments increased the seed yield range (8.04 -13.84 qt/ha) and gross (range Rs. 29880 to 41530) income over control (Rs. 24120). However, Hexaconazole treatment with its highest seed yield (13.84 qt/ha) gave highest additional income (17400 Rs/ha). This was followed by Propiconazole, Azoxystrobin, Captan+Hexaconazole, Thiophanate methyl, Wettable sulphur, Difenconazole, Chlorothalonil and Carbendazim, which had given seed yield of 12.92, 12.36, 11.61, 11.40, 11.07, 10.58, 10.41 and 9.96 qt/ha, respectively, gross income of Rs. 38760, 37080, 34830, 34200, 33210, 31740, 31230 and 29880, respectively and additional income of Rs. 14640, 12960, 10710, 10080, 9090, 7620, 7110 and 5760, respectively.

Considering the incremental cost: benefit ratio (ICBR), the most economical treatment which recorded the highest benefit ratio (1:2.86) was Hexaconazole. This was followed by Wettable sulphur (1:2.26), Captan+Hexaconazole 1:2.22), Azoxystrobin (1:1.79), Carbendazim (1:1.56), Propiconazole (1:1.53), Difenconazole (1:1.49), Thiophanate methyl (1:1.43) and Chlorothalonil (1:1.03).

Thus, among all the treatments Hexaconazole followed by Wettable sulphur and Captan+Hexaconazole was found most effective against pea powdery mildew and also most economical for management of disease.

Table 4. Economics of fungicides for control of powdery mildew of pea Cv. AP-3 (Cost : Benefit ratio)

Sr. no.	Treatments	Mean PDI	Yield (qt/ha)	Gross income/ha (Rs.)*	Addit. Income/ Ha (Rs.)	Fungicides**	Cost of cultivation (Rs.)			Net profit/ha	C:B ratio
							Labour	Other expenditure	Total		
1	T ₁ - Carbendazim (0.1%)	17.17 (24.48)	9.96	29880	5760	850	400	1000	2250	3510	1:1.56
2	T ₂ - Wettable sulphur (0.3%)	15.39 (23.10)	11.07	33210	9090	1386	400	1000	2786	6304	1:2.26
3	T ₃ - Chlorothalonil (0.2%)	16.11 (23.66)	10.41	31230	7110	2200	400	1000	3600	3500	1:1.03
4	T ₄ - Propiconazole (0.1%)	12.68 (20.86)	12.92	38760	14640	4375	400	1000	5775	8865	1:1.53
5	T ₅ - Hexaconazole (0.1%)	11.50 (19.82)	13.84	41530	17400	3100	400	1000	4500	12900	1:2.86
6	T ₆ - Thiophanate Methyl (0.1%)	14.31 (22.23)	11.40	34200	10080	2750	400	1000	4150	2930	1:1.43
7	T ₇ - Azoxystrobin (0.02%)	13.78 (21.79)	12.36	37080	12960	3240	400	1000	4640	8320	1:1.79
8	T ₈ - Difenconazole (0.05%)	15.82 (23.44)	10.58	31740	7620	1840	400	1000	3240	4830	1:1.49
9	T ₉ - Captan+ Hexaconazole (0.1%)	14.26 (22.19)	11.61	34830	10710	1920	400	1000	3320	7390	1:2.22
10	T ₁₀ - Control (Water spray)	31.69 (34.26)	8.04	24120	-	-	-	-	-	-	-

*selling rates of pea @ 3000 Rs./qt **as per cost mentioned in Chapter III Figures in parenthesis are arc sine transformed values

4.3 Management with botanicals and bioagents

Total nine, five botanicals and four bioagents were evaluated under field condition against powdery mildew of pea using susceptible variety AP-3 during Rabi, 2013 (PLATE VI). Results obtained in respect of disease incidence, severity, per cent disease control, seed yield and cost : benefit ratio are presented here in following paragraphs.

4.3.1 Effect of botanicals and bioagents on powdery mildew disease incidence

To study the effect of botanicals and bioagents on powdery mildew incidence an experiment was carried out and results obtained were presented in Table. 5 and graphically depicted in Fig. 6. Results revealed that all the botanicals and bioagents were found effective and significantly reduced the powdery mildew incidence over control.

The powdery mildew disease incidence was observed before spraying was ranged from 10.36% to 20.23% and average incidence was 14.96%. The disease incidence was found to be increased after first spray and it was ranged from 38.81% to 56.27% (Avg. 46.26%). After second and third spray disease incidence was reduced significantly after first spraying. After second spray, the disease incidence was ranged from 32.00 to 61.56 % and average incidence was 41.14%. After third spray, the disease incidence was ranged from 26.61 to 66.56 % and average incidence was 38.61%.

The results revealed that after first, second and third spray plot sprayed with bioagent *Trichoderma viride* recorded minimum disease incidence 38.81, 32.00 and 26.61 %, respectively and it was significantly superior over all other fungicide treatments. It was at par with *Pseudomonas fluorescens* and *Metarrhizium anisopliae* which recorded 40.15 and 40.60%, respectively after first spraying and 34.17 and 34.50% disease incidence, respectively after second spraying. And after third spray it was followed by *Pseudomonas fluorescens* (31.57%) and *Metarrhizium anisopliae* (31.68%). Like wise, among the botanicals, Ginger extract was showed least disease incidence 45.06, 38.49 and 36.92% after first, second and third spray, respectively and this was at par with *Ipomea* leaf extract recorded disease incidence 48.94, 41.5

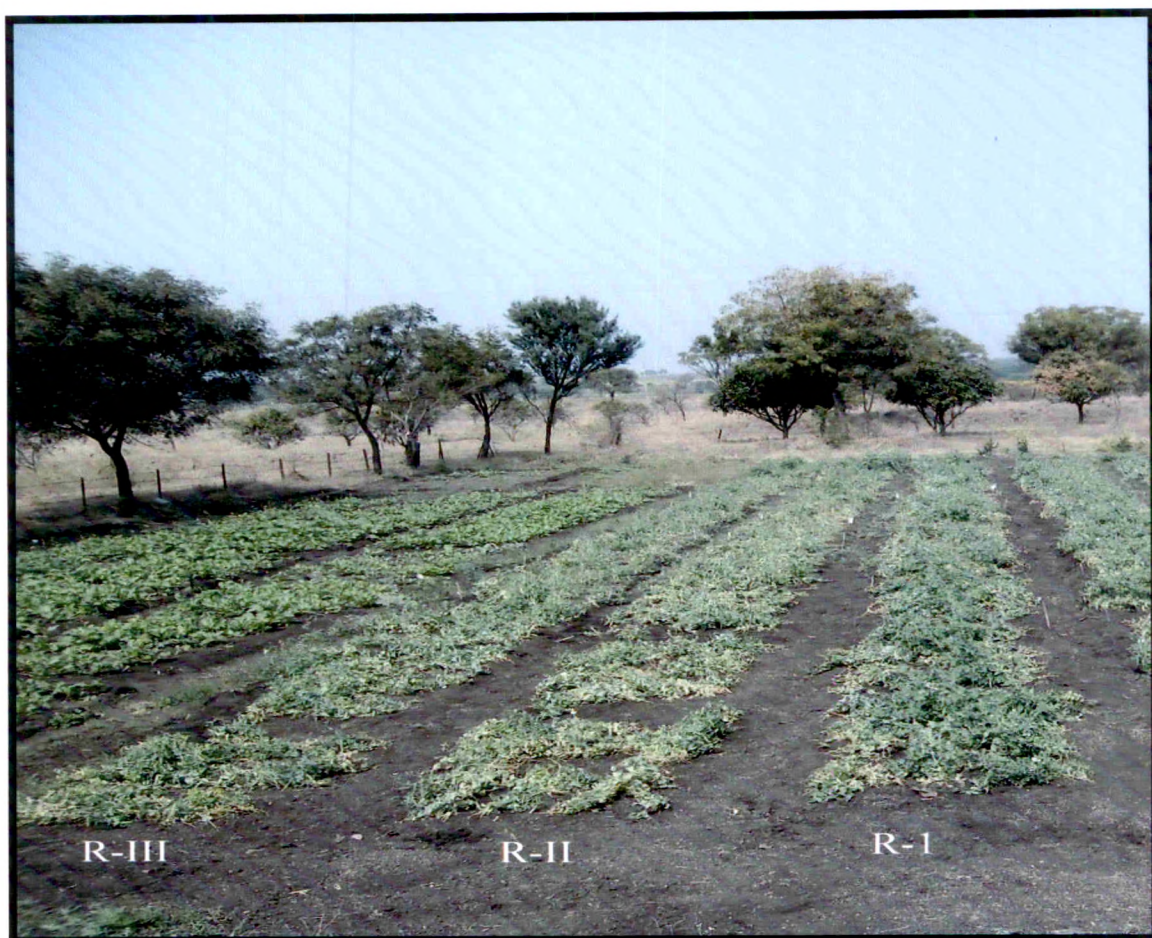


PLATE VI. Field view of an experiment on effect of botanicals and bioagents against powdery mildew of pea Cv. AP-3

Table 5. Effect of botanicals and bioagents on powdery mildew disease incidence in pea Cv. AP-3.

Sr. no	Treatments	Disease incidence (%)				
		Before spraying	After first spraying	After second spraying	After third spraying	Mean
1	T ₁ - Neem leaf extract (10%)	17.64 (24.84)	48.46 (44.17)	41.87 (40.32)	38.45 (38.32)	36.60 (37.23)
2	T ₂ - Ginger extract (5%)	13.15 (21.26)	45.06 (42.16)	38.49 (38.34)	36.92 (37.42)	33.40 (35.30)
3	T ₃ - <i>Ipomea</i> leaf extract (10%)	10.36 (18.77)	48.94 (44.39)	41.59 (40.16)	38.11 (38.12)	34.75 (36.12)
4	T ₄ - Nirgudi (10%)	15.08 (22.85)	50.65 (45.37)	44.38 (41.77)	40.72 (39.65)	37.71 (37.88)
5	T ₅ - Menthol (10%)	20.23 (26.73)	52.10 (46.20)	46.02 (42.71)	42.83 (40.88)	40.29 (39.40)
6	T ₆ - <i>Pseudomonas fluorescens</i> (0.4%)	12.29 (20.52)	40.15 (39.32)	34.17 (35.77)	31.57 (34.18)	29.54 (32.92)
7	T ₇ - <i>Trichoderma viride</i> (0.4%)	15.40 (23.10)	38.81 (38.53)	32.00 (34.45)	26.61 (31.05)	28.20 (32.07)
8	T ₈ - <i>Metarrhizium anisopliae</i> (0.4%)	13.74 (21.76)	40.60 (39.58)	34.50 (35.97)	31.68 (34.25)	30.13 (33.29)
9	T ₉ - <i>Verticillium lecani</i> (0.4%)	13.29 (21.28)	41.59 (40.16)	36.82 (37.36)	32.67 (34.86)	31.09 (33.89)
10	T ₁₀ - Control (Water spray)	18.48 (25.46)	56.27 (48.60)	61.56 (51.68)	66.56 (54.67)	50.72 (45.41)
S. E $\pm$		1.216	1.318	1.353	1.888	1.444
C.D at 5%		3.612	3.916	4.02	3.530	3.769

Figures in Parentheses are sine transform values

and 38.11% after first, second and third spray, respectively. The maximum disease incidence was observed in plot sprayed with water 56.27, 61.56% and 66.56% after first, second and third spray, respectively over all other treatments. Mean disease incidence indicated that maximum mean disease incidence was observed in Menthol 40.29% and minimum mean disease incidence was observed in *Trichoderma viride* 28.30% which was at par with *Pseudomonas fluorescens* recorded 29.54%.

4.3.2 Effect of botanicals and bioagents on powdery mildew disease severity

To study the effect of botanicals and bioagents on powdery mildew severity an experiment was carried out and results obtained were presented in Table. 6 and graphically depicted in Fig.7. Results revealed that all the botanicals and

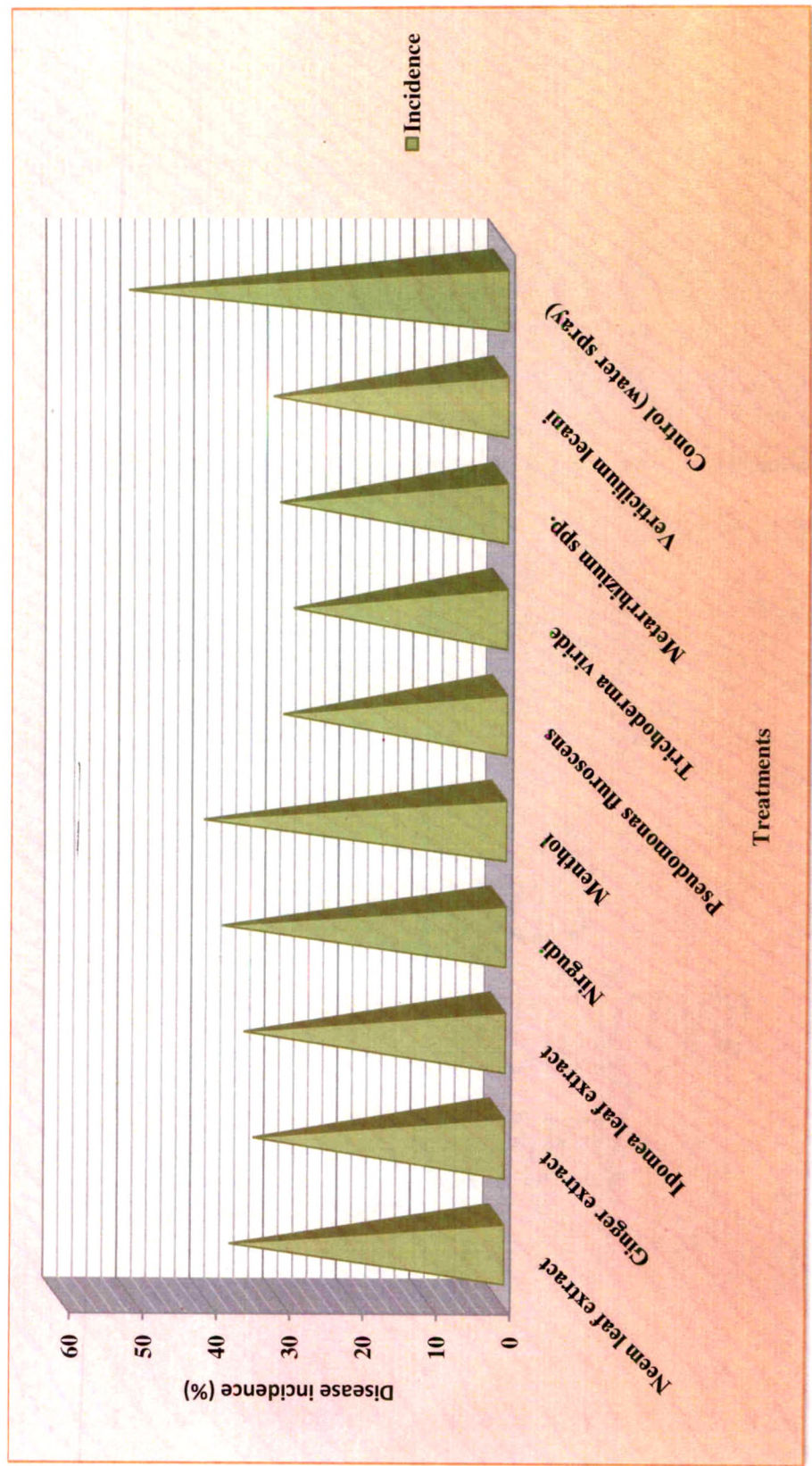


Fig. 6. Effect of botanicals and bioagents on powdery mildew disease incidence of pea Cv. AP-3

bioagents were found effective and significantly reduced the powdery mildew severity over control.

Table 6. Effect of botanicals and bioagents on powdery mildew disease severity in pea Cv. AP-3

Treatments		Disease severity (%)					Per cent disease control
		Before spraying	After first spraying	After second spraying	After third spraying	Mean	
1	T ₁ - Neem leaf extract (10%)	9.63 (18.08)	42.39 (40.62)	37.75 (37.91)	29.81 (33.10)	29.89 (33.14)	29.79
2	T ₂ - Ginger extract (5%)	8.53 (16.98)	39.57 (38.98)	34.35 (35.88)	27.30 (31.50)	27.43 (31.58)	35.56
3	T ₃ - <i>Ipomea</i> leaf extract (10%)	5.92 (14.09)	42.77 (40.84)	37.17 (37.57)	27.35 (31.53)	28.29 (32.13)	33.54
4	T ₄ - Nirgudi (10%)	8.15 (16.59)	44.17 (41.65)	38.35 (38.26)	32.76 (34.91)	30.86 (33.75)	27.51
5	T ₅ - Menthol (10%)	11.06 (19.42)	45.44 (42.38)	40.22 (39.36)	35.36 (36.49)	33.02 (35.07)	22.43
6	T ₆ - <i>Pseudomonas fluorescens</i> (0.4%)	7.45 (15.84)	34.27 (35.83)	29.20 (32.71)	22.38 (28.23)	23.32 (28.87)	45.22
7	T ₇ - <i>Trichoderma viride</i> (0.4%)	8.26 (16.70)	31.85 (34.36)	27.23 (31.45)	20.73 (27.08)	22.02 (27.98)	48.27
8	T ₈ - <i>Metarrhizium anisopliae</i> (0.4%)	6.67 (14.96)	35.47 (36.55)	29.67 (33.00)	24.30 (29.53)	24.03 (29.35)	44.55
9	T ₉ - <i>Verticillium lecani</i> (0.4%)	7.21 (15.57)	37.30 (37.64)	31.94 (34.41)	25.46 (30.30)	25.48 (30.31)	40.14
10	T ₁₀ - Control (Water spray)	10.37 (18.78)	49.24 (44.56)	53.19 (46.82)	57.48 (49.30)	42.57 (40.72)	-
S. E $\pm$		2.222	2.960	1.246	1.566	1.998	-
C.D at 5%		NS	8.796	3.701	4.653	5.938	-

Figures in Parentheses are sine transform values

Results showed that the powdery mildew severity observed before spraying was ranged from 6.67 to 11.06 % and average severity was 8.32%. However, even after first spraying, per cent disease severity was found to be more after spraying. Disease severity recorded after first spray was ranged from 31.85 to 45.44 % and average severity was 40.25 %, irrespective of treatments as against 49.24% in control plot. After second and third spray, the per cent disease severity was found to be decreased significantly compared with per cent disease severity observed after first spraying.

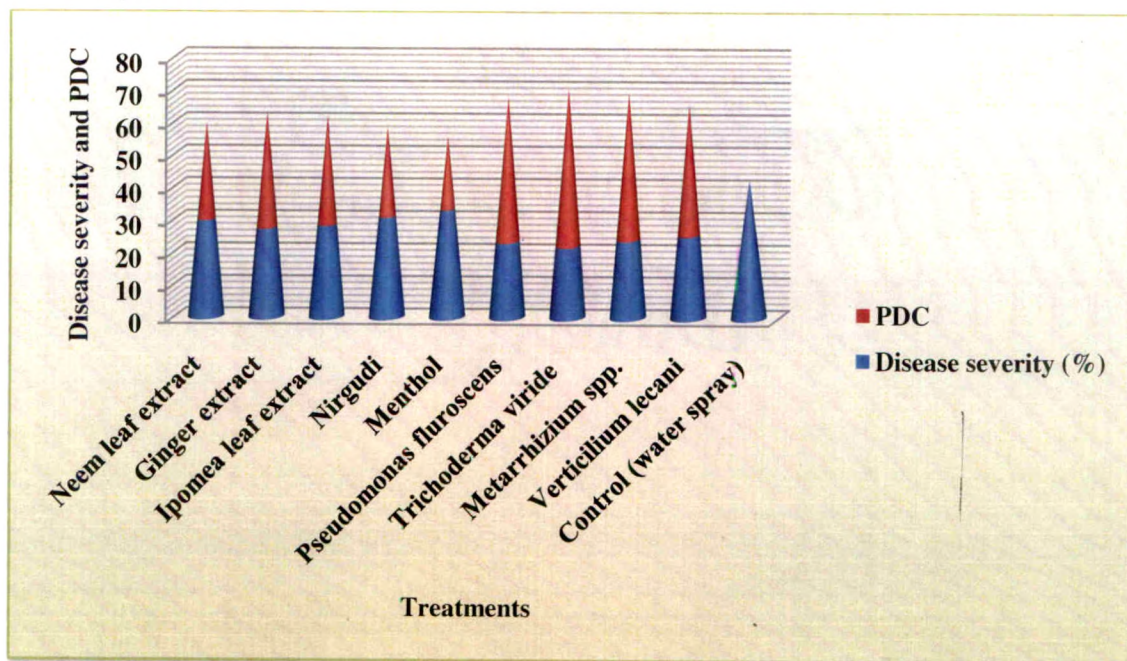


Fig. 7. Effect of botanicals and bioagents on disease severity and per cent disease control of powdery mildew of pea Cv. AP-3

After second spray, the disease severity was ranged from 27.23 to 40.22 % and average severity was 35.64%. The lowest disease severity was recorded from the plots sprayed with *Trichoderma viride* (27.23%) which was at par with *Pseudomonas fluorescens* (29.20%) and *Metarrhizium anisopliae* (29.67%) and followed by *Verticillium lecani* (31.94%). Among botanicals, Ginger extract (34.35%) recorded minimum disease severity and it was at par with *Ipomea* leaf extract (37.17%) and neem leaf extract (37.75%). The plot sprayed with water (control) exhibits maximum disease severity (53.19%).

Powdery mildew severity was recorded after application of third spray in the range of 20.73 to 35.36%. The plot sprayed with *Trichoderma viride* showed lowest per cent disease severity 20.73% which was at par with *Pseudomonas fluorescens* (22.38%) and *Metarrhizium anisopliae* (24.30%), *Verticillium lecani* (25.46%), respectively. Among botanicals, Ginger extract recorded minimum disease severity 27.30% and it was at par with *Ipomea* leaf extract (27.35%) and Neem leaf extract (29.81%). The plot sprayed with water (control) exhibits maximum disease severity (57.48%).

The mean powdery mildew disease severity in all treatments ranged from 22.02 to 42.57 %. *Trichoderma viride* spraying treatment recorded significantly least mean severity (22.02%) which was at par with *Pseudomonas fluorescens* (23.32%) and *Metarrhizium anisopliae* (24.03%) and *Verticillium lecani* (25.48%), respectively. Among botanicals Ginger extract (27.43%) recorded minimum mean disease severity which was at par with *Ipomea* leaf extract (28.29%), Neem leaf extract (29.89%), Nirgudi (30.86%) and Menthol (33.02%), respectively. The plot sprayed with water (control) exhibited maximum mean disease severity (42.57%).

Per cent disease control (PDC) over control treatment for treatments was calculated and depicted in Table 6 and Fig. 7. The results revealed that the highest disease control of 48.27% was recorded by bioagent *Trichoderma viride*. This was followed by *Pseudomonas fluorescens* (45.22%) and *Metarrhizium anisopliae* (44.55%) and *Verticillium lecani* (25.46%). Among botanicals, Ginger extract recorded maximum per cent disease control (35.56%) and followed by *Ipomea* leaf extract (33.54%), Neem leaf extract (29.79%), Nirgudi (27.51%) and menthol (22.43%), respectively.

4.3.3 Effect on grain yield

The results presented in Table 7 and graphically in Fig. 8 indicated that all the treatments, significantly reduced and effectively controlled the powdery mildew severity and increased the grain yield over control. The yield in respect of all treatments ranged from 8.15 to 10.23 qt/ha as against 6.74 qt/ha in control plot.

Table 7. Effect of botanicals and bioagents on powdery mildew of pea as affected by disease incidence, severity and yield in pea Cv. AP-3

Sr. no	Treatments	Disease incidence (%)	Disease severity (%)	Per cent disease control	Yield (qt/ha)	% increase over control
1	T ₁ - Neem leaf extract (10%)	36.60 (37.23)	29.89 (33.14)	29.79	8.27	22.70
2	T ₂ - Ginger extract (5%)	33.40 (35.30)	27.43 (31.58)	35.56	8.53	26.56
3	T ₃ - <i>Ipomea</i> leaf extract (10%)	34.75 (36.12)	28.29 (32.13)	33.54	8.32	23.44
4	T ₄ - Nirgudi (10%)	37.71 (37.88)	30.86 (33.75)	27.51	8.09	20.03
5	T ₅ - Menthol (10%)	40.29 (39.40)	33.02 (35.07)	22.43	8.15	20.92
6	T ₆ - <i>Pseudomonas fluorescens</i> (0.4%)	29.54 (32.92)	23.32 (28.87)	44.55	9.82	45.70
7	T ₇ - <i>Trichoderma viride</i> (0.4%)	28.20 (32.07)	22.02 (27.98)	48.27	10.23	51.78
8	T ₈ - <i>Metarrhizium anisopliae</i> (0.4%)	30.13 (33.29)	24.03 (29.35)	45.22	9.45	40.21
9	T ₉ - <i>Verticillium lecani</i> (0.4%)	31.09 (33.89)	25.48 (30.31)	40.14	9.17	36.05
10	T ₁₀ - Control (Water spray)	50.72 (45.41)	42.57 (40.72)	-	6.74	00.00
SE ±		1.444	1.998	-	0.587	-
CD at 5%		3.769	5.938	-	1.744	-

Figures in Parentheses are sine transform values

Highest grain yield (10.23 qt/ha) with lowest disease severity (22.02%) was recorded with *Trichoderma viride* which was at par with *Pseudomonas fluorescens* (grain yield: 9.82 qt/ha and mean disease severity: 23.32%), *Metarrhizium anisopliae* (grain yield: 9.45 qt/ha and mean disease severity: 24.03%) and *Verticillium lecani* (grain yield: 9.17 qt/ha and mean disease severity: 25.48%). Among the botanicals, Ginger extract given maximum yield i.e. 8.53 qt/ha and mean disease severity: 27.43% which was at par with *Ipomea* leaf extract (grain yield: 8.32 qt/ha and mean disease severity:

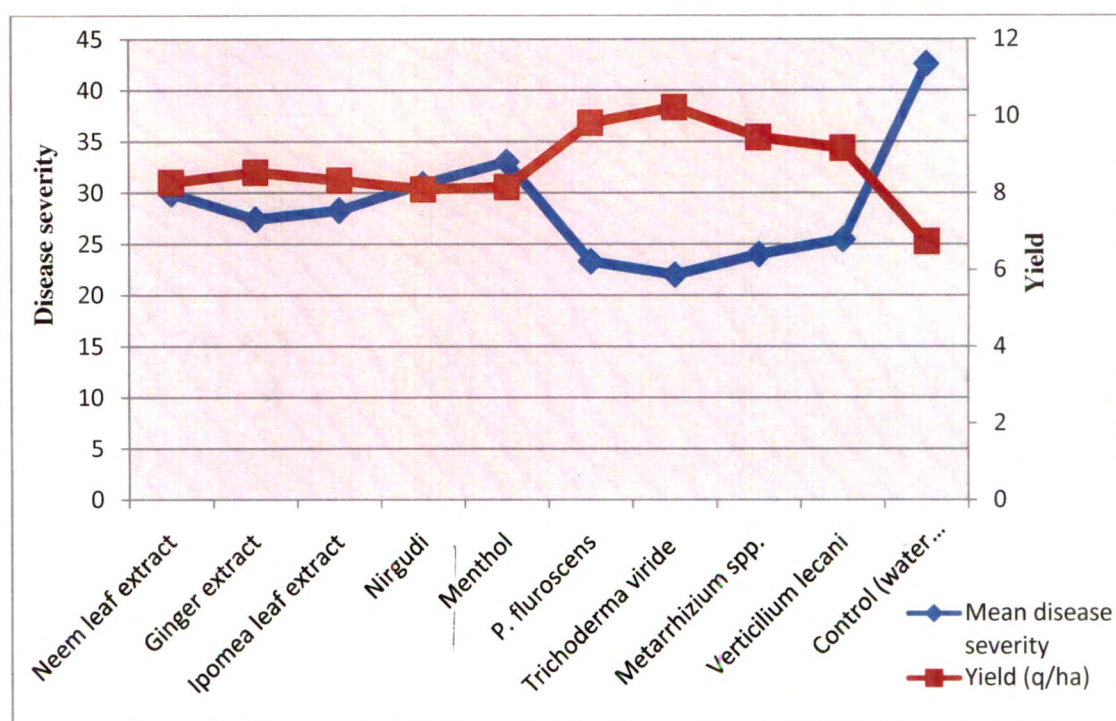


Fig. 8. Effect of botanicals and bioagents on powdery mildew disease severity and yield of pea Cv. AP-3

28.29) and Neem leaf extract (grain yield: 8.27 qt/ha and mean disease severity: 29.89%).

All the treatments significantly increased the grain yield over control (Table 7). The per cent in grain yield was ranged from 20.03 to 51.78%. However, highest grain yield (51.78%) was recorded with *Trichoderma viride* followed by *Pseudomonas fluorescens* (45.70%), *Metarrhizium anisopliae* (40.21%) and *Verticilium lecani* (36.05%). Among the botanicals, Ginger extract given highest grain yield (26.56%) followed by *Ipomea* leaf extract (23.44%), Neem leaf extract (22.70%), Menthol (20.92%) and Nirgudi (20.03%), respectively.

4.3.4 Cost: Benefit ratio

Results obtained on economics/incremental cost benefit ratio (ICBR) in respect of various spray treatments presented in Table 8. Results revealed that, the effect of powdery mildew severity resulted in maximum seed yield, maximum gross and additional income over control and given significant cost benefit ratio.

All the treatments increased the seed yield range (6.74 to 10.23 qt/ha) and gross (range Rs. 24270 to 30960) income over control (Rs. 20220). However, *Trichoderma viride* recorded highest seed yield (10.23 qt/ha) and given highest additional income (10740 Rs/ha). This was followed by *Pseudomonas fluorescens*, *Metarrhizium anisopliae* and *Verticilium lecani*, which was given seed yield of 9.82, 9.45 and 9.17qt/ha, respectively, and gross income of Rs. 29460, 28350 and 27510, respectively and additional income of Rs. 9240, 8610 and 6930, respectively. Among the botanicals, Ginger extract given highest seed yield (8.53 qt/ha) gave highest gross income (25590 Rs/ha) income over control. This was followed by *Ipomea* leaf extract, Neem leaf extract, Menthol and Nirgudi which given seed yield of 8.32, 8.27, 8.15 and 8.09 qt/ha, respectively, gross income of Rs. 24960, 24810, 24450 and 24270, respectively and additional income of Rs. 4740, 4590, 4320 and 4050, respectively.

Considering the incremental cost: benefit ratio (ICBR), the most economical treatment which recorded the highest benefit ratio (1:4.37) was *Trichoderma viride*. This was followed by *Pseudomonas fluorescens* (1:3.62), *Metarrhizium anisopliae* (1:3.30) and *Verticilium lecani* (1:2.46). Among the

Table 8. Economics of botanicals and bioagents for control of powdery mildew of pea Cv. AP-3 (Cost : Benefit ratio)

Sr. no.	Treatments	Mean PDI	Yield (qt/ha)	Gross income/ha (Rs.)*	Addit. Income/ Ha (Rs.)	Botanicals and bioagents**	Cost of cultivation (Rs.)			Net profit/ha	C:B ratio
							Labour	Other expenditure	Total		
1	T ₁ - Neem leaf extract (10%)	29.89 (33.14)	8.27	24810	4590	-	400	1000	1400	3190	1:2.28
2	T ₂ - Ginger extract (5%)	27.43 (31.58)	8.53	25590	5370	500	400	1000	1900	3470	1:1.83
3	T ₃ - <i>Ipomea</i> leaf extract (10%)	28.29 (32.13)	8.32	24960	4740	-	400	1000	1400	3340	1:2.38
4	T ₄ - Nirgudi (10%)	30.86 (33.75)	8.09	24270	4050	-	400	1000	1400	2650	1:1.89
5	T ₅ - Menthol (10%)	33.02 (35.07)	8.15	24450	4320	500	400	1000	1900	2420	1:1.27
6	T ₆ - <i>Pseudomonas fluorescens</i> (0.4%)	23.32 (28.87)	9.82	29460	9240	600	400	1000	2000	7240	1:3.62
7	T ₇ - <i>Trichoderma viride</i> (0.4%)	22.02 (27.98)	10.23	30690	10740	600	400	1000	2000	8740	1:4.37
8	T ₈ - <i>Metarrhizium anisopliae</i> (0.4%)	24.03 (29.35)	9.45	28350	8610	600	400	1000	2000	6610	1:3.30
9	T ₉ - <i>Verticillium lecani</i> (0.4%)	25.48 (30.31)	9.17	27510	6930	600	400	1000	2000	4930	1:2.46
10	T ₁₀ - Control (Water spray)	42.57 (40.72)	6.74	20220	-	-	-	-	-	-	-

*selling rates of pea @ 3000 Rs/qt

**as per cost mentioned in Chapter III

Figures in parenthesis are arc sine transformed values

botanicals the most economical treatment which recorded the highest benefit ratio (1:2.38) was *Ipomea* leaf extract. This was followed by Neem leaf extract (1:2.28), Nirgudi (1:1.89), Ginger extract (1:1.83) and Menthol (1:1.27)

Thus, among all the treatments, bioagent *Tricoderma viride* and *Pseudomonas fluorescence*. In plant extracts Ginger extract was found most effective and *Ipomea* leaf extract and Neem leaf extract was found most economical for management of disease.

4.4 Varietal/cultivar screening

Total 7 cultivars/varieties/hybrids of pea were screened under natural epiphytotics for their reactions to powdery mildew disease to trace out the source of resistance (PLATE VII). The data on disease severity, incidence, average pods/plant, average grains/pod and yield (gm)/plant is given in Table 9 and 10.

Results of Table 9 indicate that per cent disease incidence was ranged from 26.38 to 48.56%. The less disease incidence was observed in Latur local-2 (26.38%) and this followed by GS-10 (34.26%), Captain (37.43%), Soldier (41.62%) and Arkel (44.68%), respectively. The highest disease incidence was recorded in Latur local-1 (48.56%). The disease severity was ranged from 19.34 to 41.28%. The least disease severity was recorded in Latur local-2 (19.34%) and this was followed by GS-10 (27.58%), Captain (31.51%), Soldier (34.79%), Arkel (38.28%), respectively. The highest disease severity was recorded in Latur local-1 (41.28%). Average pods/plant was ranged from 7 to 16. The minimum number of pods per plant was recorded in Latur local-2 (7) and maximum 16 pods/plant was recorded in GS-10. Average grains per pod was ranged from 4 to 8 and minimum and maximum grains per pod were recorded in Latur local-2 (4 grains/pod) and GS-10 (8 grains/pod). Yield per plant was ranged from 1.69 to 15.42 gm. The lowest yield was recorded in Latur local-2 (1.69 gm/plant) and the highest yield was recorded in GS-10 (15.42 gm/plant)

Based mean PDI, all the 7 varieties/cultivars of pea evaluated categorized as: Resistant (R), Moderately resistant (MR), Moderately susceptible (MS), Susceptible (S) and Highly susceptible (HS).

Results Table (10) revealed that of the 7 varieties/cultivars/hybrids screened, one (Latur local-2) was moderately resistant and six (Soldier, AP-3,



PLATE VII. Field view of pea varieties/cultivars screening against powdery mildew of pea

Captain, Arkel, GS-10 and Latur local-1) were moderately resistant. Out of the tested varieties none was recorded as resistant, susceptible and highly susceptible to disease.

Table 9. Screening of pea varieties / hybrids against powdery mildew of pea.

Sr · N o	Varieties/hybrid	Mean disease incidence (%)	Mean disease severity (%)	Reaction	Average pods / plant	Average grains / pod	Yield (gm)/ plant
1	Soldier	41.62	34.79	MS	12	6	11.24
2	AP-3	46.51	38.28	MS	13	7	14.56
3	Captain	37.43	31.51	MS	11	6	8.71
4	Arkel	44.68	37.46	MS	12	7	13.28
5	GS-10	34.26	27.58	MS	16	8	15.42
6	Latur local-1	48.56	41.28	MS	10	7	4.24
7	Latur local-2	26.38	19.34	MR	7	4	1.69

Table 10. Varietal reaction of pea varieties/ hybrids against powdery mildew of pea under field condition

PDI range	Reaction	Varieties/cultivars
0	Immune (I)	None
1-10	Resistant (R)	None
11-25	Moderately resistant (MR)	Latur local-2
26-50	Moderately susceptible (MS)	Soldier, AP-3, Captain, Arkel, GS-10, Latur local-1
51-75	Susceptible (S)	None
>76	Highly susceptible (HS)	None



DISCUSSION



CHAPTER V

DISCUSSION

Pea (*Pisum sativum* L.) is a valuable vegetable crop all over the world. India is recognized globally as the major producer of pulses contributing 25 per cent to the global production. In India, area, production and productivity of pea during 2012-13, was about 4.18 lakh ha, 3,942 thousand MT and 9.4 MT/ha and in Maharashtra, it was about 0.1 lakh ha, 51 thousand MT and 5.1 MT/ha (Anonymous, 2013). The major pea producing states are Bihar, Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Odisha and Karnataka. Uttar Pradesh ranks first in production.

Among the various factors responsible for low production and productivity of pea, disease caused by bacteria, fungi and viruses are the major one. Of the fungal diseases infecting pea, powdery mildew incited by *Erysiphe polygoni* DC is one of the most important and destructive disease, inflicting heavy yield losses to the tune of 50-90% (Surwase *et al.*, 2009).

Keeping in view, spread in disease susceptibility and losses incurred by *Erysiphe polygoni* pathogen, present investigations on the aspects viz., effect of fungicides, botanicals and bioagents against powdery mildew disease of pea and varietal screening against powdery mildew disease were undertaken during Rabi, 2013 at Department of Plant Pathology, College of Agriculture, Latur. The results obtained on above aspects during the present investigations are being discussed here in the following paragraphs.

5.1 Symptomatology

In the field the disease first appeared on the leaves and then on other green parts of the plants. White floury patches are evident on both the sides of leaves and on tendrils, pods and stem etc. The patches originated as minute discoloured specks from which powdery mass radiates on all sides. These patches become whitish to ash coloured and pod formation was also reduced.

White powdery spot of powdery mildew further increased in number, enlarged and coalesced to form big whitish blotches covering entire leaf surface. Heavily infected plants exhibited apparently talcum powder like appearance.

Similar, symptoms under field conditions on pea, mungbean was reported earlier by Rangaswami (1988).

5.2 Efficacy of fungicides against powdery mildew disease

5.2.1 Efficacy of fungicides on powdery mildew disease incidence in pea

Results revealed that all the treatments significantly influenced the powdery mildew disease incidence in pea. The mean per cent disease incidence recorded with all the treatments was ranged from 19.03 to 25.94%. All the nine fungicides significantly reduced disease incidence over control (42.55%). However, Hexaconazole was found most effective and recorded least disease incidence 19.03%. Similar results was reported by Khunti *et al.* (2002), Banyal and Rana (2003), Singh (2007), Surwase *et al.* (2009) and Kacchot (2011). The second best fungicide was Propiconazole which recorded minimum disease incidence 20.29%. Such effectiveness of Propiconazole was reported earlier by Nargund *et al.* (2012), Basandrai *et al.* (2013) and Hiremath (2013). This was followed by Azoxystrobin (22.07%), Captan+Hexaconazole (22.40%), Thiophanate methyl (23.10%), Wettable sulphur (23.75%), Difenconazole (24.15%), Chlorothalonil (24.44%) and Carbendazim (25.94%), respectively. Effectiveness of Captan+Hexaconazole, Thiophanate methyl, Wettable sulphur and Carbendazim was reported by Mathur and Shekhawat (1998), Rettissanababady *et al.* (2000), Singh and Tomar (2007), Nargund (2012), Adinarayana (2013) and Hiremath (2013).

5.2.2 Efficacy of fungicides on powdery mildew disease severity in pea

Results indicated that all the treatments were found effective and significantly reduced the powdery mildew severity over control in pea. The mean per cent disease severity recorded with all the treatments was ranged from 11.50 to 17.17%. All the nine fungicides significantly reduced disease severity over control (31.69%). Among the fungicides tested, Hexaconazole recorded least disease severity 11.50% and there by caused highest reduction (63.71%) in disease severity. Similar results was reported by Khunti *et al.* (2002), Banyal and Rana (2003), Singh (2007), Surwase *et al.* (2009) and Kacchot (2011). The second best treatment was spraying of Propiconazole which recorded least mean severity (12.68%) and per cent disease control was 59.99%. Such effectiveness of Propiconazole was reported earlier by

Nargund *et al.* (2012), Basandrai *et al.* (2013) and Hiremath (2013). This was followed by Azoxystrobin (mean disease severity: 13.78% and disease control: 56.52%), Captan+Hexaconazole (mean disease severity: 14.26% and disease control: 55.00%) Thiophanate methyl (mean disease severity: 14.31% and disease control: 54.84%), Wettable sulphur (mean disease severity: 15.39% and disease control: 51.43%), respectively. Effectiveness of Captan+Hexaconazole, Thiophanate methyl and Wettable sulphur was reported by Mathur and Shekhawat (1998), Singh and Tomar (2007) and Adinarayana (2013).

5.2.3 Efficacy of fungicides on yield in pea

Results revealed that all the fungicides evaluated were found effective in reducing the powdery mildew disease incidence and severity thereby given increased grain yield over control in pea.

Among the fungicides tested Hexaconazole (0.1%) recorded least disease severity (11.50%) and significantly highest grain yield of 13.84 qt/ha. Similar result was reported by Surwase *et al.* (2009) and Kacchot (2011). The second and third highest yield was recorded by Propiconazole (12.92 qt/ha) and Azoxystrobin (12.36 qt/ha) and this was followed by Captan+Hexaconazole (11.61 qt/ha), Thiophanate methyl (11.40 qt/ha), Wettable sulphur (11.07 qt/ha), Difenoconazole (10.58 qt/ha), Chlorothalonil (10.41 qt/ha), Carbendazim (9.96 qt/ha) and control (water spray) (8.04 qt/ha). Mathur and Shekhawat (1988) and Surwase *et al.* (2009) reported effectiveness of Carbendazim in increase seed yield of pea. Effectiveness of Wettable sulphur was reported by Vikas and Ratnoo (2011).

5.2.4 Economics (cost: benefit ratio) of fungicides

The results obtained on economics (cost: benefit ratio) of the spraying of fungicides for control of powdery mildew disease of pea revealed that, all the treatments significantly reduced the disease incidence and severity and thereby increased the grain yield with more gross and additional income over control.

Considering cost: benefit ratio, the most economical treatment found with highest cost: benefit ratio (1:2.86) was Hexaconazole. Similar results was reported by Khunti *et al.* (2002) and Banyal and Rana (2003). This was followed by Wettable sulphur (1:2.26) and Captan+Hexaconazole (1:2.22). Such results of highest

cost: benefit ratio of Wettable sulphur was reported by Nema and Krishna (1982), Das and Narin (1990) and Suryawanshi *et al.* (2009).

5.3 Efficacy of botanicals and bioagents against powdery mildew disease

5.3.1 Efficacy of botanicals and bioagents on powdery mildew disease incidence in pea

Results revealed that all the treatments significantly influenced the powdery mildew disease incidence in pea. The mean per cent disease incidence recorded with all the treatments was ranged from 28.20 to 40.29%. All the nine treatments significantly reduced disease incidence over control (50.72%). However, *Trichoderma viride* was found most effective and recorded least disease incidence 28.20%. Similar results was reported by Sharma and Jat (2011) and Jagtap and Khalikar (2012). This was followed by *Pseudomonas fluorescens* (29.54%) was reported by Rankhode (2011) and Jagtap and Khalikar (2012). Among the botanicals Ginger extract was found least disease incidence 33.40% was reported by Singh *et al.* (1991).

5.3.2 Efficacy of botanicals and bioagents on powdery mildew disease severity in pea

Results indicated that all the treatments were found effective and significantly reduced the powdery mildew severity over control in pea. The mean per cent disease severity recorded with all the treatments was ranged from 22.02 to 33.02%. All the nine fungicides significantly reduced disease severity over control (42.57%). Among the tested treatments, bioagent *Trichoderma viride* recorded least disease severity 22.02% and there by caused highest reduction (48.27%) of disease severity. Similar results was reported by Sharma and Jat (2011) and Jagtap and Khalikar (2012). The second least mean severity and second highest per cent disease control was recorded by *Pseudomonas fluorescens* (mean disease severity: 23.32% and disease control: 45.22%). Effectiveness of *Pseudomonas fluorescens* was reported by Rankhode (2011) and Jagtap and Khalikar (2012). Among the botanicals Ginger extract was showed least disease severity 27.43% and highest per cent disease control 35.56% was reported by Singh *et al.* (1991).

5.3.3 Efficacy of botanicals and bioagents on yield in pea

Results revealed that all the botanicals and bioagents evaluated were found effective in reducing the powdery mildew disease incidence and severity thereby given increased grain yield over control in pea.

Among all the treatments tested, highest grain yield (10.23 qt/ha) with lowest disease severity (22.02%) was recorded with *Trichoderma viride*. Similar result was reported by Sharma and Jat (2011). which was at par with *Pseudomonas fluorescens*, *Metarrhizium anisopliae*, *Verticillium lecani*, *Ipomea* leaf extract, Neem leaf extract, Menthol and Nirgudi which recorded grain yield of 9.82, 9.45, 9.17, 8.32, 8.27, 8.15 and 8.09 qt/ha, respectively. Among the botanicals Ginger extract given maximum yield i.e. 8.53 qt/ha.

5.3.4 Economics of (cost :benefit ratio) of botanicals and bioagents

The results obtained on economics (cost: benefit ratio) of the spraying of fungicides for control of powdery mildew disease of pea revealed that, all the treatments significantly reduced the disease incidence and severity and thereby increased the grain yield with more gross and additional income over control.

Considering the incremental cost: benefit ratio (ICBR), the most economical treatment which recorded the highest benefit ratio (1:4.37) was *Trichoderma viride*. This was followed by *Pseudomonas fluorescens* (1:3.62). Among the botanicals, the most economical treatment which recorded the highest benefit ratio (1:2.38) was *Ipomea* leaf extract. This was followed by Neem leaf extract (1:2.28), Nirgudi (1:1.89), Ginger extract (1:1.83) and Menthol (1:1.27).

These results obtained on economics of fungicidal sprayings for the management of powdery mildew of pea and in other leguminous crops are in conformity with those reported earlier by Surwase *et al.* (2009).

5.4 Varietal/cultivar screening

Seven pea cultivars/varieties screened under natural epiphytotics against powdery mildew disease. Results indicated that per cent disease incidence was ranged from 26.38 to 48.56%. The less disease incidence was observed in Latur local-2 (26.38%) and the highest disease incidence was recorded in Latur local-1 (48.56%).

Of the 7 varieties screened none was found resistant to the disease. Out of them 6 varieties were found moderately susceptible with PDI in the range of 27.58 to 41.28% and only in Latur local-2 was found moderately resistant with 19.34% per cent disease severity.

Several workers have also recorded previously the powdery mildew disease reaction in pea varieties such as Saharan and Gupta (1983), Thakur *et al.* (1988), Mathur *et al.* (1991), Hooda *et al.* (2010), Muhammad *et al.* (2010) and Kapoor *et al.* (2013).

Average pods/plant was ranged from 7 to 16. The minimum and maximum number of pods per plant were recorded in Latur local-2 (7) and GS-10 (16). Average grains per pod was ranged from 4 to 8 and minimum and maximum grains per pod were recorded in Latur local-2 (4) and GS-10 (8). Yield per plant was ranged from 1.69 to 15.42 gm. The lowest yield was recorded in Latur local-2 (1.69 gm) and the highest yield was recorded in GS-10 (15.42 gm).

Regarding pods/plant and grains/pod such results was earlier found by Muhammad *et al.* (2010).

CHAPTER VI

SUMMARY

Pea (*Pisum sativum* L.) is a valuable vegetable crop all over the world. In India, the major pea producing states are Bihar, Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Odisha and Karnataka. Among the different fungal diseases attacking the crop, powdery mildew incited by *Erysiphe polygoni* DC is one of the most important and destructive disease, inflicting heavy yield losses to the tune of 50-90% (Surwase *et al.*, 2009). During recent years, powdery mildew is attacking on many crops and posing threat in the production.

The typical symptoms of small, round and circular whitish spot appeared on surface of leaves. The results obtained on the efficacy of nine fungicides Carbendazim, Wettable sulphur, Chlorothalonil, Propiconazole, Hexaconazole, Thiophanate methyl, Azoxystrobin, Difenoconazole, Captan+Hexaconazole and Control (water spray) revealed that all the spray treatments significantly reduced the powdery mildew incidence, severity and increased grain yield in pea.

Among all the treatments, Hexaconazole (0.1%) was found most effective and recorded significantly least mean disease incidence (19.03%) and severity (11.50%) with corresponding significantly increased grain yield (13.84 qt/ha). The second best treatment found was Propiconazole (0.1%) which recorded mean disease incidence and severity of 20.29% and 12.68%, respectively with grain yield of 12.92 qt/ha. The third best treatment was Azoxystrobin (0.02%) which recorded mean disease incidence and severity of 22.07% and 13.78%, respectively with corresponding increased grain yield of 12.36 qt/ha.

Based on cost benefit ratio, Hexaconazole had highest cost: benefit ratio of 1:2.86 and found to be effective and economical for the management of powdery mildew disease of pea. The second and third best cost: benefit ratio found were Wettable sulphur (1:2.26) and Captan+Hexaconazole (1:2.22). These were of found most economical and effective for the management of powdery mildew of pea, respectively.

The results obtained on the efficacy of four bioagents, *Pseudomonas fluorescens*, *Trichoderma viride*, and *Metarrhizium anisopliae* and five botanicals, Neem leaf extract, Ginger extract, *Ipomea* leaf extract, Nirgudi and Menthol revealed that all the spray treatments significantly reduced the powdery mildew incidence, severity and increased grain yield in pea.

Among the bioagents *Trichoderma viride* (0.4%) recorded significantly least mean disease incidence (28.20%) and severity (22.02%) with corresponding increased grain yield (10.23 qt/ha). The second best treatment found was *Pseudomonas fluorescens* (0.4%) which recorded mean disease incidence and severity of 29.54% and 24.03%, respectively with grain yield of 9.82 qt/ha. Among the botanicals, Ginger extract (5%) recorded significantly least mean disease incidence (33.40%) and severity (27.43%) with corresponding increased grain yield (8.53 qt/ha). The second best botanical found was *Ipomea* leaf extract (10%) recorded mean disease incidence and severity of 34.75% and 28.29%, respectively with grain yield of 8.32 qt/ha.

Based on cost benefit ratio, of the treatment *Trichoderma viride* had highest cost: benefit ratio of 1:4.37 and found to be effective and economical for the management of powdery mildew disease of pea. The second and third best cost: benefit ratio found was *Pseudomonas fluorescens* (1:3.62). Among the botanicals, *Ipomea* leaf extract was found best regarding cost: benefit ratio i.e. 1:2.38 and this followed by Neem leaf extract which recorded 1:2.28. These were found most economical and effective for the management of powdery mildew of pea.

Of the 7 varieties/cultivars of pea evaluated under field conditions against *Erysiphe polygoni*, the lowest disease incidence was found in Latur local-1 and out of seven varieties, one (Latur local -2) found Moderately resistant and six found Moderately susceptible. The highest average pods per plant, average grains per pod and yield per plant were recorded in GS-10.

CONCLUSION

Thus from the results obtained on various aspects during present investigations on powdery mildew (*Erysiphe polygoni*) of pea (*Pisum sativum*) can be concluded that

- Studies on field efficacy of fungicides against *Erysiphe polygoni* proved that 2-3 sprays of the fungicides viz., Hexaconazole, Propiconazole, Azoxystrobin, Captan+Hexaconazole and Wettable sulphur could effectively and economically manage powdery mildew disease of pea.
- Studies on efficacy on botanicals and bioagents against *Erysiphe polygoni* proved that in bioagent 2-3 sprays of *Trichoderma viride*, *Pseudomonas fluorescens* and *Metarrhizium anisopliae*. In botanicals, Ginger extract, *Ipomea* leaf extract and Neem leaf extract could effectively and economically manage the powdery mildew disease of pea.
- Out of seven varieties, one (Latur local-2) found Moderately resistant and six found Moderately susceptible for powdery mildew disease. Therefore, need to be further extensive screening of large material to find out resistant source.



*LITERATURE
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ABSTRACT

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Title: "Management of Powdery mildew of Pea Incited by *Erysiphe polygoni* DC."

ABSTRACT

Powdery mildew caused by *Erysiphe polygoni* DC of pea (*Pisum sativum* L.) has been found to affect severely and cause accountable qualitative and quantitative yield losses to the tune of 50-90% (Surwase *et al.*, 2009). Present investigations on *Erysiphe polygoni* were carried out during Rabi, 2013 with the objectives viz., management with fungicides, botanicals and bioagents and varietal screening at the Department of Plant Pathology, College of Agriculture, Latur.

All the nine fungicides and five botanicals and four botanicals evaluated under field condition were found effective against *Erysiphe polygoni* over control (water spray). However, among the fungicides Hexaconazole (0.1%) recorded the least mean disease incidence (19.03%), severity (11.50%) with corresponding high yield 13.84 (qt/ha) and thereby highest per cent disease control (63.71%). This was followed by Propiconazole (0.1%) and Azoxystrobin (0.02%). Considering the incremental cost : benefit ratio (ICBR) the most economical treatment which recorded the highest cost : benefit ratio (1:1.79) was Hexaconazole. Among the botanicals Ginger extract (5%) recorded least mean disease incidence, severity, highest yield and percent disease control i.e. 33.40, 27.43, 35.56% and 8.53 qt/ha, respectively with highest cost:benefit ratio (1:4.37). Likewise, among the bioagents *Trichoderma viride* recorded least mean disease incidence (28.20%), severity (22.02%) and high yield (10.23 qt/ha). Among the bioagents the highest cost :benefit ratio was recorded in Ipomea leaf extract (1:2.38).

Among the seven varieties screened under natural epiphytotics revealed that one, Latur local-2 was moderately resistant and six, Soldier, AP-3, Captain, Arkel, GS-10 and Latur local-1 were moderately susceptible.

ANNEXURE

OILSEED RESEARCH STATION, LATUR

Week wise Meteorological data during the period of investigation

M.W.	Date	Total rain fall (mm)	Rainy days (No.)	Temp		Relative Humidity (%)	
				Min.	Max.	I	II
1	29 Oct-4Nov.	0	0	18.4	28.7	70.1	64.0
2	5-11Nov.	0	0	17.8	28.5	63.3	42.4
3	12-18 Nov.	0	0	14.5	27.4	62.9	46.0
4	19-25 Nov.	21.6	2	13.9	29.0	65.1	47.1
5	26-Nov.2Dec.	0	0	15.6	28.0	67.9	60.9
6	3-9 Dec.	81	1	13.6	26.1	61.3	54.0
7	10-16 Dec.	0	0	9.7	27.0	47.0	50.9
8	17-23 Dec.	0	0	9.8	28.1	55.4	57.0
9	24-31 Dec.	0	0	12.3	26.9	53.9	38.6
10	1-7 Jan, 2014	0	0	12.1	28.2	52	44
11	8-14 Jan	0	0	12.0	29.3	59	48
12	15-21 Jan	0	0	15.2	29.2	53	59
13	22-28 Jan	0	0	14.4	26.6	55	56
14	29 Jan-4 Feb	0	0	12.6	28.2	56	35
15	5-11 Feb	0	0	12.7	30.5	57	25
16	12-18 Feb	0	0	12.2	27.6	51	35
17	19-25 Feb	0	0	12.2	29.5	51	45
18	26 Feb-4 March	23.2	3	15.7	27.8	69	52

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